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Computer Supported Education

7th International Conference, CSEDU 2015
Lisbon, Portugal, May 23–25, 2015
Revised Selected Papers

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Preface

This book includes extended and revised versions of a set of selected papers from CSEDU 2015 (the 7th International Conference on Computer Supported Education), held in Lisbon, Portugal, May 23–25, 2015, which was sponsored by the Institute for Systems and Technologies of Information, Control and Communication (INSTICC). This Conference was held in cooperation with ACM SIGITE – ACM Special Interest Group for Information Technology Education, ACM SIGMIS – ACM Special Interest Group on Management Information Systems, ATIEF – Association des Technologies de l'Information pour l'Education et la Formation, SPEE – Portuguese Society for Engineering Education, ECBE – European Council for Business Education, IELA – International E-Learning Association, and ASEE – American Society for Engineering Education. The conference was also technically co-sponsored by IGIP – International Society for Engineering Education.

The purpose of the CSEDU series of conferences is to bring together researchers and practitioners interested in methodologies and applications related to the education field. The conference had five main topic areas, covering different aspects of computer-supported education, including "Information Technologies Supporting Learning," "Learning/Teaching Methodologies and Assessment," "Social Context and Learning Environments," "Domain Applications and Case Studies." and "Ubiquitous Learning."

The program of this conference included several outstanding keynote lectures presented by internationally renowned distinguished researchers who are experts in the various CSEDU areas, including (alphabetically): Rob Koper (Open University of the Netherlands, Netherlands), Neil Morris (University of Leeds, UK), Edmundo Tovar (Madrid Polytechnic University, Spain), and Glenn Wintrich (Dell, USA). Their keynote speeches contributed to the overall quality of the program and significance of the theme of the conference.

CSEDU 2015 received 196 paper submissions from 48 countries in all continents, of which 20 % were accepted as full papers. The high quality of the papers received imposed difficult choices in the review process. To evaluate each submission, a double-blind paper review was performed by the Program Committee, whose members are highly qualified independent researchers in the CSEDU 2015 topic areas.

This book contains the revised papers selected among the best contributions, taking also into account the quality of their presentation at the conference, assessed by session chairs. Therefore, we hope that you find these papers interesting, and we trust they may represent a helpful reference for all those who need to address any of the aforementioned research areas.

We wish to thank all those who supported and helped to organize the conference. On behalf of the conference Organizing Committee, we would like to thank the authors, whose work was critical to the success of the conference, and the members of the Program Committee, whose expertise and diligence were instrumental for the quality of the final contributions. We also wish to thank all the members of the

Organizing Committee, whose work and commitment were invaluable. Last but not least, we would like to thank Springer for their collaboration in getting this book to print.

May 2015

Markus Helfert
Maria Teresa Restivo
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Invited Paper

Open Education Practices as Answer to New Demands of Training in Entrepreneurship Competences: The Role of Recommender Systems

Edmundo Tovar[1(✉)], Nelson Piedra[2], Jorge López[2], and Janneth Chizaiza[2]

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Abstract. Entrepreneurship in Europe is a priority as a powerful driver of economic growth and job creation. The increasing demand for this skill and to reduce unemployment requires innovative ways to train. This paper present the StartUp model composed by the redefinition of Entrepreneurship in terms of competences and an Open Educational Practice based on an Open Learning Architecture including steps of a quality lifecycle model for OER. A critical component of this model, the recommender system is described. This work has been done in the context of the European Project StartUp funded with support of the European Commission.

Keywords: OER · OEP · Open Educational Practice · Entrepreneurship · Competences · Recommender system · Linked data

1 The Entrepreneurial Spirit in Europe

Competences related to entrepreneurship are considered a key factor to put in place in this period of economic recession. The Communication from the Commission to the Council, the European Parliament, the European Economic and Social committee and the Committee of the Regions – "Implementing the Community Lisbon Programme: Fostering entrepreneurial mind-sets through education and learning", COM(2006) 33 final [1] declares that entrepreneurship is a key competence for growth, employment and personal fulfilment and that the education systems can greatly contribute to successfully addressing the entrepreneurial challenge within the EU.

The unemployment crisis that this project is addressing are well-known: "the impact of the crisis on employment and the social situation increased as the unemployment rate rose from less than 7 % in 2008 to 10.8 % in 2013, putting 9 million more people out of work. The effects were unevenly spread across the EU however, with unemployment rates in 2013 still only around 5 % in Austria and Germany against over 25 % in Greece and Spain" [2].

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The skills that the European Union identified as crucial for the new job market may be summarised in the following points: flexibility/adaptability; effective communications skills; problem solving; creativity; interpersonal skills; teamwork [3]. OER can potentially be a powerful tool in order to develop these new skills that the new knowledge society developed after the crisis requires.

We also need to consider the fact that, across Europe, many more people will struggle to access higher education in the future as fees are raised and current unemployment levels have an effect on our ability to afford traditional education.

Today a massive number of multilingual OER collections are available online. The growth of the OER movement over the past decade has meant that it has become more and more difficult to have an overview of OER initiatives globally, and even locally. One of the main objectives of StartUP therefore, is to help users to use them more effectively, by bringing a huge range of resources, focussing on enterprise skills, together in one platform that will provide a structured procedure to access sources from around the world.

2 Entrepreneurship and the Startup Model as an Open Education Practice (OEP)

The StartUP model has been the main result carried out under the StartUp project (www.startupproject.eu), a 32 month project co-funded with support by the European Commission. Its general objective is to enhance the professional skills of learners (school and university teachers and students, trainers, trainees, informal and non-formal learners) using open and flexible, ICT-innovative and pedagogically-rich and tailored learning paths with a specific focus on the development, extension and expansion of entrepreneurial skills.

The overall aim of the StartUP project is to develop an innovative pedagogy and assessment approach, based on OER (Open Educational Resources) to support the diverse individual learning pathways and to better assess all types of learning outcomes and future learning needs related to entrepreneurship competences.

The StartUp model is composed of two components: a definition of the Entrepreneurship concept based on competences and the elements of the Open Educational Practice offered to develop the Entrepreneurship.

2.1 The Entrepreneurial Competences Matrix

Different methodologies and different tools were designed and used during the research activities. Initially a desktop research was employed to catalogue and systematize school and academic curricula in the entrepreneurship field in all the Project partner countries (i.e. in Italy, Austria, Spain, Malta and the UK), as well as the corporate training programmes in the different sectors and for different business roles. Sharing previous experience with other ongoing projects was very useful in completing the desktop research on entrepreneurial competences. Different tools have been elaborated and used by the partner as online questionnaire (for external partners and for stakeholders), Guidelines for interviews and Guidelines for Focus Groups. Research involved experts (internal and external), stakeholders, trainers of secondary schools and adult trainers.

The "Entrepreneurial Competences Matrix" (Fig. 1) is the result of these research activities. The Matrix groups competence area in four "Cluster": "Business skills", "Management skills", "Communication skills" and "Self-development skills". For each competence Description of the competence in the entrepreneurial context (examples) and related Learning Outcomes are provided. The Matrix constitutes the shared knowledge base for the StartUp open practice. The competences listed in the Matrix are linked to the Open Educational Resources to be included in the StartUP model.

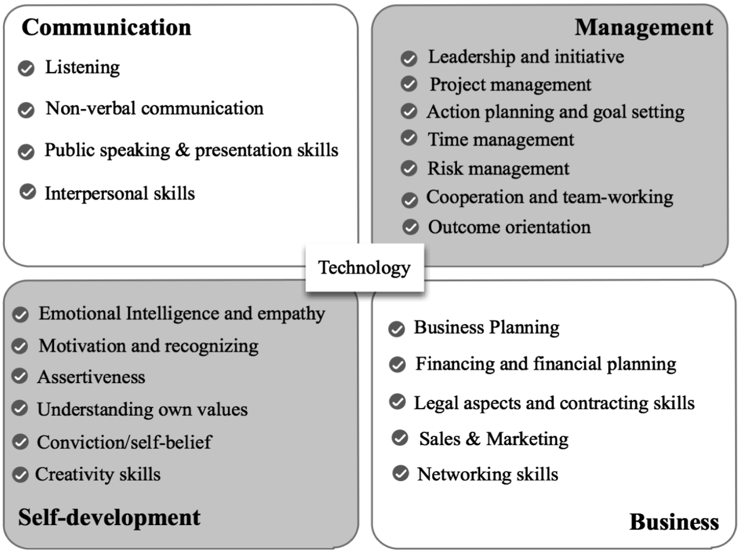

Fig. 1. Clusters and skills of an entrepreneur.

2.2 The Startup Open Education Practice

All the work done by the partners has been clearly managed as an Open Educational Practice (OEP) as well as its quality, trying to integrate in its results a typical lifecycle model for OER.

The rationale behind this open practice and the reason the consortium was developed, was based on the fact that only a minimum amount of Open Educational Resources (OER) and tools available online are currently used in the lifelong learning sector and vocational education training. The Open practice is analyzed in detail along the Sect. 3: In Sect. 3.1 there is reflection about the challenges for Open Educational Practices and how these ones match with OER components of the StartUp model. A complete description of the importance and impact of the results produced by the recommender system of this model is showed in the Sect. 3.2. Conclusions are summarized in Sect. 4.

3 Critical Factors in Open Education Practices

The report "Beyond OER" [4] came to the conclusion that OER are in principal available but are not frequently used, by several causes: (1) lack of institutional support, (2) lack of technological tools for sharing and adapting resources, (3) lack of skills and time of users, (4) lack of quality or fitness of OER, (5) personal issues like lack of trust and time. These are the challenges of successful Open Educational Practices, defined by two dimensions, openness in resource usage and creation and openness in pedagogical models [5].

These causes help us to identify the issues we consider keys to have a successful open practice, that in our opinion are the existence of productive communities, diffusion and adaption of OERs, OER quality and localization and the personalized learning.

- **Communities:** There has been a growing interest in recent years in Communities of Practice (CoP) and Networks of Practice (NoP) in connection with informal knowledge gathering, notably in the fields of education and both knowledge management and innovation within organisations. Lave and Wenger [6] define a community of practice as "a set of relations among persons, activity and world, over time and in relation with other tangential communities of practice".
  In simple terms, communities of practice are groups of people who share a common pursuit, activity or concern. Members do not necessarily work together, but form a common identity and understanding through their common interests and interactions.
  Many different communities of practice exist and we may all be members of several, for example, through our work or hobbies. They are often informal and self-managed. For some communities of practice we may be a core member, whereas for others we may sit on the periphery. Communities of practice are repositories of explicit or formal knowledge.
  However, like CoPs, members often participate in several networks of practice. Networks of practice have the same features as communities of practice but may have weaker ties [7].
  The stakeholders of Open Educational Practices are the 'open educational governance' community, i.e. those actors who are involved in open education from all perspectives. In this case this practice is aimed at all educators, students and self-learners of any age and professional background, who have an interest in enterprise and wish to develop their skills using OER.
- **Diffusion and Adoption of OER:** An organisation commencing from a zero state, from which it moves to develop competence in OER, when it is able to develop OER competence among only a small quantum of learners (even be it high competence), it will only manage what we call a 'Silent representation'. An OER ambition can however be successfully underpinned if the development of OER competence is widely adopted by learners throughout an organisation. In the case of such a collective learning ambition, with a clear strategic intent, the organisations likely to move from 'Silent representation' towards 'Successful strategic exploitation' [8].

- **Quality and OER Localization:** Teachers and students as prospective creators of OER are the main actors to develop a culture of quality within their own respective local communities of practice. Institutions supporting development and use of OER can also to adopt these quality guidelines in their internal quality assurance practices.
  Defining quality in absolute terms is elusive because it depends upon whose perspective we choose to adopt. However, quality has been fairly well defined by Harvey and Green [9] as being on five dimensions, with Fitness for Purpose as the dimension most relevant to quality for open educational resources (OER). Fitness for Purpose indicates that the purpose needs to be defined, and this depends on whose perspective we adopt. An OER highly rated as excellent quality by students in their remedial learning, but which teachers elsewhere find terribly difficult to adapt, change the language, and relocalise to another culture and context.
  An OER highly rated as excellent quality by students in their remedial learning, but which teachers elsewhere find terribly difficult to adapt, change the language, and relocalise to another culture and context. So, on one level the OER is high quality, but on another higher level this same OER is low quality and unusable.
  There are three levels were originally designed to visualise the processes of localisation and internationalisation, according to the level of the reusers: depending on whether they were the intended end-users (notably the student learning), were the intermediate users (the providers, teachers, or translators), or were the store-keeper users (the repositories, portals and institutions) [10].
- **Personal Learning Environment (PLEs):** The proliferation of learning innovations such as personal devices, granular and distributed applications, services, and resources, requires the learner to develop his or her own strategies for managing the various information streams and tools to support learning. A PLE is created by learners in the process of designing and organising their own learning,. PLEs are distinctly learner-centred and foster autonomous learning. PLEs are interconnected in a digital ecosystem of media, tools and services and act as a gateway to an open and connected learning experience. This approach marks a shift towards a model of learning in which learners draw connections from a pool of digital and non-digital building blocks, aggregating, mixing and combining them into unique constellations as part of learning.
  While emphasizing the active role of a learner, the PLE approach implies that learning is not located in a specific time and place, but is an ongoing, ubiquitous and multi-episodic process. As PLEs allow the collocation of diverse learning activities, tools, and resources, contexts permeate and learning becomes connected [11].

3.1 Challenges of the Startup Model vs Architectural Basic Components

The StartUp model can be considered as an Open Learning Architecture where a high degree of openness in pedagogical models in combination with a high degree of OER usage and creation result in a high degree of maturity of OEP in which OERs are used [12]. It encompasses:

– An innovative method for evaluating the learning needs of individual users in the entrepreneurial sector. This is possible by using a virtual expert able to provide users with suitable individual training paths, based on their specific needs and using the most effective contents which are freely available online.
– An online peer review community will ensure the quality of the OER contents included in the learning sets.

The StartUp Open Learning Architecture is composed basically by a virtual expert that simulates the behaviour of a real expert, an authoring system, allowing all users to take an active part in the process of development/localization/remix of OERs, and a rating system, stimulate discussions among the target group and promote collaborative and peer to peer learning. All these three basic components constitute the basic StartUp model and the model as a whole matches the main challenges highlighted before as critical to the success of open practices: personal learning environment (Virtual expert), localization and quality (authoring system and rating system).

- The *Virtual Expert* simulates a real expert conducting, in a flexible and smart way, a multidimensional analysis on users' training needs, taking into account data such as personal interests, age, educational background, prior knowledge, learning style, etc. The Virtual Expert processes users' data and produce a set of recommended resources to fulfill their training needs and the acquisition of new competences, creating a personalized training set with OERs corresponding to a particular user profile. At the end of the training needs process the virtual expert will summarize user's training needs in the entrepreneurship field recommending an optimal training path (made by OERs) to be pursued to achieve professional goals and new competences with an estimate of the time for their achievement.
- The *Authoring System* (i.e. "Share your OER") allows users to take an active part in the process of development/localization/remix of OERs. Users not only benefit by the chance to learn through OERs calibrated on their profile, but also actively participate in the improvement and customization of the training sets.
  Users can actually take an active part in the process of development/localization/remix of OER using an authoring system made available to them. The user will be able to develop an OER from scratch to adapt/remix an existing OER both in term of contents and format, translate and localize an existing OER, and to link to an OER, stored in an OER repository, as it is.
  The distinguishing feature of OER is the freedom with which they can be used, reused and repurposed thanks to their open licence. Several of the steps of an evolved lifecycle model such as editing, evaluation and use/repurposing [4]. In OER, these steps do not happen consecutively, but instead, they can happen simultaneously in the processes of 'checking and editing', or 'checking and approving'. Then each system of the architecture is described more in detail emphasizing how the open features of OER are managed.

  – Initiating the creation of the 'idea' of the learning resource – the process whereby the initial author decides on a set of learning objectives the resource should be designed to address.

- Describing the learning resource using metadata, which is defined as structured data about an object that supports functions associated with the designated object. The metadata follow the LOCWD model [13]. LOCWD is a vocabulary devoted to linking OERs, open licenses, OER/OCW repositories, and other academic information using the Web. Thanks to the LOCWD vocabulary, the system will try to automatically extract some metadata, but the user will always be able to check (and possibly correct) the metadata automatically set by the system. In case users would like to link an already available OER, the metadata that should be automatically extracted by the system are: Title, Alternative title, Abstract, Language, Tags, Author name, Author organization, Date created, OER provider, URL source, License, Encoding format, Duration.
- Checking and editing the learning resource through multiple iterations improving the resource.
- Discovering new resources. It refers to the identification of relevant learning resources and their evaluation in terms of fitness for purpose for their intended use. The StartUp model makes available a recommender system using Serendipity search tool to discover new OER. The recommender includes also an analysis of information based on social networks as twitter. With influential users identified in the network of the retweets the recommender selects the tweets that have URLs that were written by them and suggest OERs to be recommended.
- Additionally a set of processes are executed to find related hashtags published in relevant tweets and the topics associated to the keywords of search giving to the user an updated overview of the topic.

• The *Rating System* allows collaborative and peer-to-peer learning and assessment of resources. An online community is set to promote discussion and collect feedback on the training sets. Users rate the quality and relevance of OERs: assessing the "Quality" means assessing user experience about how to access and navigate into the interface, its layout, and the quality of contents; assessing the "Relevance" instead measures the relevance to the training set proposed.

- Evaluating and rating the quality and relevance as a social ranking, which can be described as a form of crowd-sourced peer-review. We consider "Quality" as the combination of two more specific parameters allowing us to conduct a multi-dimensional analysis: User experience about how to access, to navigate, effective and nice interface/layout, and the quality of the contents (clear, well explained and presented, without spelling error…). "Relevance" instead wants to measure the actual relevance according to the OER users. The trend will be that only the best quality OERs will remain in the training lists and moreover they will be part of the correct training sets thanks to the relevance parameter.
- Repurposing: Also concerning the relevance, an OER must be rated at least a certain number of times (threshold to be defined) because of statistical significance. Users who consider an OER of little relevance must specify the reason. For this, specific closed form questions will be asked the users to allow the automation of the process. Only after a certain number of error notifications the

system will modify the metadata and reallocate the OER in the right training set (corresponding to the right profile). In this way, the system will automatically and continuously improve the fruition of the training lists thanks to the collective intelligence of the community who will use it.

3.2 A Critical Problem: Feeding OERs to the OER Gateway Through the Recommender System

The components described above are not sufficient to ensure the success of an open practice. Creating communicates from scratch requires the use of the platform has enough appeal and interest to potential users interested in training in entrepreneurship. Issues as stimulation for registration of new users, and a sufficient number of users for this community can not be ignored and hope that they enroll spontaneously. The size of the communities is essential to ensure the expected results, and influences largely critical factors noted above, as the adoption of the platform for target groups provided with access to sufficient resources since the moment of the creation of the community, the increment of more OERs available, better quality of these OERs ordered by relevance and a more accurate selection of training paths adapted to the user's needs.

That is the reason it has been included a recommender system.

This is responsible for nurturing the community with an important set of resources organized by competencies and filtered by relevance. The Recommender is a function of the system which provides users with more resources then the OERs selected for the training set. It helps discovering new resources with the Serendipity search tool, use such resources as basis for new OERs, it helps networking through the suggestion of Twitter accounts and hashtags (analysis of keywords) and present users several food for thought (see Fig. 2).

The StartUP model uses the LOCWD model, a vocabulary devoted to linking OERs, open licenses, OER/OCW repositories, and other academic information using the Web. The LOCWD vocabulary is available in http://purl.org/locwd/schema/ and was defined by the UPM. Following the LOCWD model and completing them with metadata directly related to the objectives of the project, i.e., data about cluster of competences and competences, we use the following list of metadata which will describe univocally each OER selected/localized/remixed/developed both by partners and StartUP platform users. Due to the StartUP metadata assuming the LOCWD vocabulary, the system will automatically extract many of the metadata recommended by the system, but the user will always be able to check (and possibly correct) the metadata automatically set. In case users would like to link an already available OER, the metadata that should be automatically extracted by the system are: Title, Alternative title, Abstract, Language, Tags, Author name, Author organization, Date created, OER provider, URL source, License, Encoding format and Duration.

The description of the types of resources that feeds this system is essential to understand the impact of this with respect to the objectives for third system. The sources of information are Serendipty search tool, twitter and topics on the web of data.

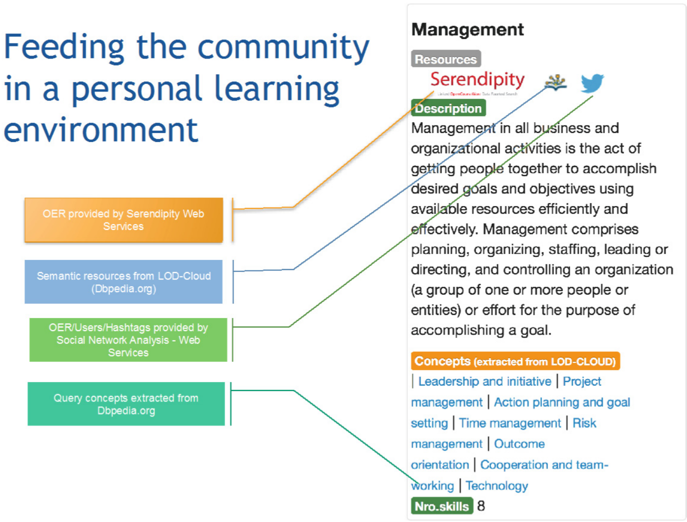

Fig. 2. Different sources to feed the StartUp model.

These resources can be openly licensed documents and media and are discovered in our model through web services. A Web service is a method of communication and a standardized way of integrating web-based application over the World Wide Web. Its objective is to provide a way to its clients to access to these resources. Web services are language and platform independent. These services are externally available, which provides a common discovery mechanism for OER consumers.

The Serendipity Component for OER Recommender. The Serendipity Web service component proposes a way aimed to simplify development of recommendation systems over Linked OER Data. Recommender system development for the Semantic Web data typically requires ontology|vocabulary, rules and rule-based inference engine to be applied over the RDF data. The design of the component focuses on three main principles: abstraction, extensibility, and interoperability. Abstraction is achieved by providing higher level of constructs. Extensibility is achieved by designing each module that is independent of the underlying implemented systems. Interoperability is achieved by to enable interchanging and integration with other systems. The application of the technique includes modeling a user's learning path needs (profile information) and resource properties based on Serendipity OER vocabulary (LOCWD). Then, a list of open educational materials recommended for the user can be generated based on recommendation rules externally defined by domain expert users, e.g. learning paths defined by entrepreneurship experts. Given a Linked OER Data Graph (G), and a user entrepreneurship learning path which contains a roadmap to launching their own development of entrepreneurship, we recommend a ranked list of resources which belong to items of G similar to a certain item i according to the user preference.

The output of this Web service is a single ranked list of OER, which is then converted into a format required by the Startup recommender system. We decide to use RDF and JSON as format for representing the resources. The recommendation processor provides algorithms for calculate the similarity value between items and make top N recommendations. Findings by competencies appear in Table 1.

OER Recommendation Based on Social Network Analysis. In these days, much of the information published on the Web is published on social media, represented through social networks such as Facebook or Twitter. Twitter is a social media network where millions of daily messages called tweets are exchanged. A tweet could have hashtags, words preceded by #, that can be used to identify the subject of the message; users, through re-tweets o RT and mentions; and may also include links to other resources that expand the original content or show interesting information.

In [14] the authors established the research problem: "Find a group of URLs posted on Twitter that can be used as OERs and that complement the training needs of a person in a particular domain." This problem has the following features and restrictions:

- The raw materials are the URLs.
- The URLs will be considered as complementary OERs.
- Need a mechanism to capture a lot of information because of the specific needs of users is unknown.
- We cannot use traditional recommendation techniques because the user profile is unknown and as said [15] this techniques would require each URL to have feedback from several users to compute reliable recommendations.

With these features, and restrictions, the solution to the problem is use alternatives techniques such as: (i) query expansion, via Link data, as a mechanism to capture a lot of information; (ii) social network analysis as a means to get recommendations, but the recommendation takes in to account only the tweets with a valid URL; (iii) the influence of users as a mechanism which guarantees the quality of the OERs.

The following tasks were executed:

- Data recollection. StartUP has an outcome called the "Entrepreneurial Competence Matrix" these competences were expanded with the aim of find related topics through the RDF triples stored in DBpedia. The competences and its extensions were used like query expressions in the API of search of Twitter. With the data collected from Twitter, the processes of harvesting and structuring are executed so that the information is ready for discovery tasks. The final data source has 70000 tweets related with the StartUP competences.
- URL enhanced. This process has the goals of: validate, disambiguated and get additional information (title, description and metatags) of the links collected. The next steps used only the tweets with valid URLs. In the data source there are 13577 valid URLs, 31646 users and 7728 hashtags.
- Social analysis. Using social network analysis, three networks were built: hashtags networks, used to identify topics associated; re-tweets and mentions networks, that allows us to find the most influential users. A metric of centrality helped us to select

Table 1. Findings of the "Serendipity" search tool.

Competence	Skill	OER	OCW
Communication	Listening	182	11
Communication	Non-verbal communication	99	12
Communication	Public speaking & presentation skills	2413	172
Communication	Interpersonal skills	332	30
Communication	Technology	75	8
Management	Leadership and initiative	17	4
Management	Leadership	438	34
Management	initiative	81	2
Management	Project management	188	10
Management	Action planning and goal setting	2	0
		24	3
Management	Time management	1832	74
Management	Risk management	1170	54
Management	Outcome orientation	1533	61
Management	Cooperation and team-working	29	0
Management	Technology	0	0
Self-development	Emotional Intelligence	214	12
Self-development	Empathy	389	28
Self-development	Motivation	1080	52
Self-development	Recognizing	362	15
Self-development	Assertiveness	166	16
Self-development	Understanding own values	209	17
Self-development	Conviction/self-belief	432	27
Self-development	Creativity skills	140	8
Business	Business Planning	563	32
Business	Financing and financial planning	125	8
Business	Legal aspects and framework	2089	84
Business	Contracting	2089	84
Business	Sales & Marketing	530	41
Business	Networking skills	3967	301

the users and hashtags outstanding. After this step the data source has 1280 users identified as influential and 1425 hashtags (related topics).

- Recovery of OERs. The URLs published by influential users were considered as OERs. The OERs recovery has 3788 URLs.

- OER ranking. With the premise of using the collective intelligence the most representative elements of the hashtags network were used to assign a score to each of the OERs.

The process described above was able to discover influential users, related topics (hashtags) and OERs for the competences defined by the StartUP project. The Table 2 shows the results.

Table 2. Results for each competence area.

Skill	OERs	Users	Hashtags
Project management	197	97	140
Emotional intelligence	99	145	59
Public speaking	57	91	42
Time management	50	61	75
Risk management	128	61	102
Goal setting	37	52	34
Presentation skills	31	56	25
Networking skills	30	46	18
Financial planning	2383	195	340
Goal setting	173	153	109
Non verbal	293	76	205
Business planning	112	78	84
Leadership initiative	132	100	36
Assertiveness	37	32	119
Interpersonal skills	24	23	17
Team working	5	14	20

Enrichment Entities by Means of Social Knowledge Sources. Meaningful OERs can be omitted during a search based-on keywords due to matching mechanism based in words.

The service of topic recommendation has been designed to take advantage of linked data sources with the purpose of enrich or extend a determined term or tag and providing enhanced results by enriching the skills that the entrepreneur requires to improve.

Through the tag cloud, an user can choose any of the recommended topics, and the system will respond by filtering the results that are associated with the term chosen.

The potential benefits of use a function that generates a related topic list are the following (i) make it more easy for the user to understand a knowledge domain, because it allows him to explore linked concepts through hierarchical relations; (ii) offer the required support in order to incorporate functions of disambiguation and information filtering, in this way, the user will be able to find the OERs which satisfies his specific learning needs.

Next, there is exposed a case in which the entities recommendation function is used in order to find Open Educational Resource based on the entrepreneur's skills.

In the context of the Web of Data, the recommendation process begins when an term of interest is recognized as a semantic resource. As a result of the expansion process, hundred of entities can be visited; therefore, a ranking function [16] must be implemented, which determines the recommended entities by relevance order.

To identify the term of interest the DBPedia ontology enables a broad coverage of entities in the world, and allows entities to bear multiple overlapping types; it includes RDF data derived from Wikipedia; each resource is harvested from a Wikipedia article (which content is maintained by thousands of editors and it broad and multilingual) [17].

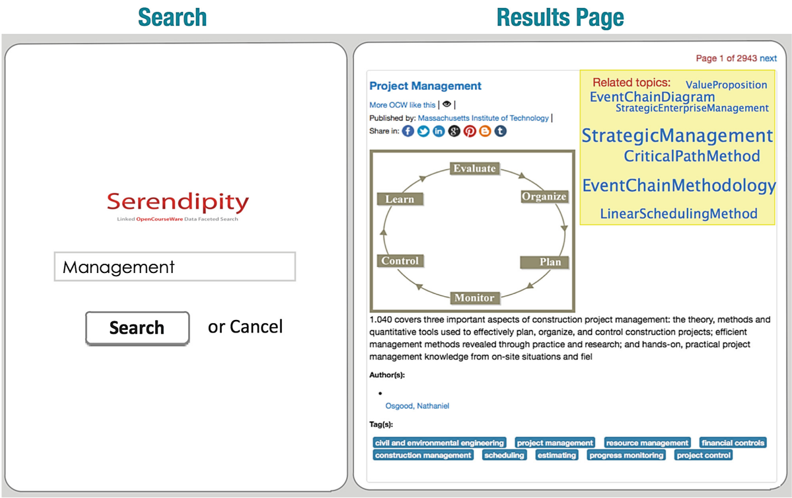

Fig. 3. Enhanced search of OER supported by a function of recommendation of topics related to a skill.

Figure 3 shows the search interface, which is used to send a request to the system. In response, the system presents a list of OERs that meet the search criteria and the topics cloud related to skill entered by the user. On the results page, for each of the related topics, the user can query its description or comment in four different languages: English, Spanish, Italian and French [18].

In Table 3, an extract of the semantic concepts related to the Management cluster are shown. The columns: low and intermediate denote the association degree of a topic with respect of a skill of interest.

In Fig. 4, a summary of the results of the recommendation services is shown. As it can see, skills related to Business and Management have the highest amount of recommended topics. On the contrary, the skill “Outcome orientation” has the least amount of recommendations. A key factor to get adequate results is to find and map each skill to the correct DBPedia category.

Table 3. Number of entities related to skills of management cluster.

Skill	Related entities according to degree association		Top-3 entities with high degree of association
	Low	Intermediate	
Leadership and initiative	66	6	Positions of authority Leadership Leadership training
Project management	288	63	Data management Information technology management Planning
Action planning and goal setting	234	17	Motivation Goal setting Ben Franklin effect
Time management	71	6	Planning Time perception Getting Things Done
Risk management	77	18	Occupational safety and health Risk Risk assessment
Outcome orientation	2	0	Motivation Goal orientation
Cooperation and team-working	187	47	Collaboration Collective intelligence Community

Communication

Skill	*Entities*
Listening	29
Non-verbal communication	82
Public speaking & presentation skills	109
Interpersonal skills	343

Business

Skill	*Entities*
Business Planning	563
Financing and financial planning	444
Legal aspects and framework and contracting skills	402
Sales & Marketing	785
Networking skills	79

Management

Skill	*Entities*
Leadership and initiative	76
Project management	371
Action planning and goal setting	281
Time management	81
Risk management	104
Outcome orientation	3
Cooperation and team-working	252

Self-development

Skill	*Entities*
Emotional Intelligence and empathy	362
Motivation and recognizing	160
Assertiveness	34
Understanding own values	31
Conviction/self-belief	23
Creativity skills	182

Fig. 4. Number of topics recommended for each skill.

4 Conclusions

Being entrepreneurship a key competence for growth, employment and personal fulfilment the education systems can greatly contribute to successfully addressing the entrepreneurial challenge within the EU.

This Open Educational Practice empowers the entrepreneurship teachers' and learners' skills by giving them the confidence and skills to successfully customize and incorporate the StartUp model so it best fits their teaching needs.

The basic StartUp model as a whole matches the main challenges highlighted as critical to the success of open practices: personal learning environment (Virtual expert), localization and quality (authoring system and rating system). But specifically, the recommender system prove easier to find and use, we can expect the number of users to greatly increase in comparison with the present beneficiaries, thus enhancing the community and allowing the creation of a virtuous learning circle. As a further result, a growing community could lead to an increase in the frequency of learning objects being uploaded for assessment that will then enrich the OERs available.

Furthermore, as at present the majority of OER are in English, we can even assume that among the community the most effective learning objects could be translated by trainers, to be used in their own courses. As a result, the OER number will grow across different languages, thus allowing more users to benefit from them.

References

1. Commission of the European Communities, COM (2006) 33 final, Implementing the Community Lisbon Programme: Fostering Entrepreneurial Mindsets Through Education and Learning, Brussels. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52006DC0033&from=EN. Accessed 13 February 2006
2. European Commission, 2015, Annual Report: Employment and Social Developments in Europe 2014. http://ec.europa.eu/social/main.jsp?catId=113
3. The Top 6 Work Skills Today's Employers Want. http://www.socialeurope.eu/2014/04/work-skills/. Accessed 15 April 2014
4. Ehlers, U.D., et al.: Beyond OER: Shifting Focus from Resources to Practices. Lisbon, Essen (2011)
5. Camilleri, A.F., Ehlers, U.D., Pawlowski, J.: State of the art review of quality issues related to open educational resources (OER). Report EUR 26624 EN, Joint Research Centre, European Commission (2014)
6. Lave, J., Wenger, E.: Situated Learning: Legitimate Peripheral Learning. Cambridge University Press, Cambridge (1991)
7. Wenger, E.: Communities of Practice, Learning, Meaning, and Identity. Cambridge University Press, New York (1998)
8. Cornelis, A., van Dorp, K.-J., Lane, A.: eLearning Papers, no. 23, ISSN: 1887-1542, www.elearningpapers.eu. Accessed March 2011
9. Harvey, L., Green, D.: Defining quality. Assess. Eval. High. Educ. **18**(1), 9–34 (1993). http://www.tandfonline.com/doi/abs/10.1080/0260293930180102#.UzU8F9xLfTQ. Accessed 28 March 2014

10. Paul, K.: Quality assurance for OER: current state of the art and the TIPS framework. eLearning Papers, no. 40, ISSN: 1887-1542. www.openeducationeuropa.eu/en/elearning_papers. Accessed January 2015
11. Ilona, B., Tapio, K. (Guest Editors): Personal Learning Environments, Issue No. 35. http://www.elearningpapers.eu/en/elearning_papers/call_for_papers
12. Tovar, E., Stefanelli, C.: Training entrepreneurship through an open educational practice. In: The StartUp model, Open Education Global Conference 2015, Banff, Canada. http://conference.oeconsortium.org/2015/wp-content/uploads/2015/02/oeglobal2015_submission_85.pdf
13. Piedra, N., Tovar, E., Colomo-Palacios, R., López, J., Chicaiza, J.: Consuming and producing linked open data: the case of OpenCourseWare. Emerald EarlyCite (2014). 10.1108/PROG-07-2012-0045
14. Lopez-Vargas, J., Piedra, N., Chicaiza, J., Tovar, E.: Recommendation of OERs shared in social media based-on social networks analysis approach. In: Proceedings of the Frontiers in Education Conference, FIE (2015)
15. Chen, J., Nairn, R., Nelson, L., Bernstein, M.S., Chi, E.H.: Short and tweet: experiments on recommending content from information streams. In: CHI 2010, Atlanta, Georgia, USA, 10–15 April 2010
16. Blanco, R., Cambazoglu, B.B., Mika, P., Torzec, N.: Entity recommendations in web search. In: Alani, H., Kagal, L., Fokoue, A., Groth, P., Biemann, C., Parreira, J.X., Aroyo, L., Noy, N., et al. (eds.) ISWC 2013, Part II. LNCS, vol. 8219, pp. 33–48. Springer, Heidelberg (2013)
17. Cano, A.E., Varga, A., Rowe, M., Ciravegna F., He, Y.: Harnessing linked knowledge sources for topic classification in social media. In: Proceedings of the 24th ACM Conference on Hypertext and Social Media, pp. 41–50 (2013)
18. Chicaiza, J., Piedra, N., Lopez-Vargas, J., Tovar, E.: Domain categorization of open educational resources based on linked data. Commun. Comput. Inf. Sci. **48**, 15–28 (2014)

Papers

Identification and Formalization of LMS Instructional Design Languages: Moodle Case Study

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Abstract. Many universities have adopted Learning Management Systems (LMSs) to offer teachers a range of pedagogical and administrative tools for supporting teaching and learning activities. However, many teachers have difficulty using these LMSs; they have to encompass the LMS technical features and services in order to understand the underlying way of designing. Despite the use of external editors, instructional engineers don't see the relationship between "how they design a learning scenario" and "how the learning session can be set up within the target LMS". If LMSs could be able to make explicit their intrinsic and implicit learning design model, it can be exploited as a proprietary format to build tools and facilities dedicated to this LMS. The research presented in this paper aims to present our method in terms of necessary analysis and steps for the identification and the formalization of such LMSs' instructional design languages. The method takes into account three different viewpoints: a viewpoint centred on the LMS macro-HMIs (Human-Machine Interfaces), a functional viewpoint and a micro viewpoint. We validate the proposed method by applying this formalization on two versions of Moodle.

Keywords: Learning management system · e-Learning · Instructional design · Operationalization · Technology enhanced learning · Process · Moodle

1 Introduction

Our research work focuses on the field of Technology Enhanced Learning (TEL) engineering and re-engineering. TEL is a scientific domain where different disciplines such Computer Science,, education, psychology, philosophy, communication or sociology intersect [1]. We are particularly interested in applying and adapting Computer Science solutions for providing practitioners with some customized instructional design solutions.

Instructional Design (ID) is the systematic development of instructional specifications using learning and instructional theories to ensure the quality of instruction. It is the entire process of analysis about learning needs and goals as well as the development of a delivery system to support those needs. It includes development of instructional materials and activities and delivering and evaluation of all instruction and learner activities [2]. It has been a well-established discipline for several decades [3].

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TEL is a large domain for research and practice, including e-learning, mobile learning, and Learning Management System (LMS). An LMS is the framework that handles all aspects of the learning process. An LMS is also the concrete infrastructure that delivers and manages instructional content, identifies and assesses individual and organizational learning or training goals, tracks the progress towards meeting those goals, and collects and presents data for supervising the learning process of organization as a whole [4]. LMSs support the use of standards for describing the learning objects, packaging them into larger content and learning units (such as lessons and courses), and applying various instructional design strategies and techniques [5]. Nowadays, LMSs are not restricted to distant learning only. Teachers use them for blended learning which combines traditional face-to-face learning with computer supported learning [6]. LMSs have created remarkable opportunities for higher education to expand the educational process beyond the traditional classroom to include geographically dispersed students [7].

The research work presented in this paper is a continuity of other former works in our lab [8, 9] by proposing a new implementation approach of learning situations and pedagogical scenarios. It takes place into the context of the GraphiT project (Graphical Visual Instructional Design Languages for Teachers). Its main goal is to study the possibilities and limits about the pedagogical expressiveness of operationalizable languages to specify future leaning scenarios that could be fully deployed and automatically set up upon an existing LMS. Such instructional design languages aim at promoting and improving the uses of current LMSs by providing practitioners with some LMS-specific designing language and authoring-tool. Despite many existing standards [10, 11], approaches [12], languages [13], architectures [14], and tools [13, 15] to facilitate the instructional design, they are often not compatible with existing LMSs, or require a costly reengineering of the LMS (new web service API, new runtime engines, etc.). Moreover, they do not simplify the operationalization of the produced models. Some translations, leading to information or semantics losses, are still required to operationalize them into a targeted LMS.

In this paper, we are focusing on the identification and formalization of LMSs implicit instructional design language. Indeed, the expected result will be the base for the development of binding solutions and will simplify the instructional design on platforms. These solutions must insure that future scenarios formalized in accordance with the language to identify will be operationalized without semantics losses into the LMS internal structures. This process is dedicated to LMSs active communities and more specifically to designers with a competence in IT and the service of information technology and communication for education (pedagogical engineers) who meets difficulties in appropriating the instructional design language of LMSs.

The paper is organized as follows. Section 2 presents related works about identifying and formalizing LMS languages. Section 3 highlights our motivation to extract the pedagogical LMS language. Section 4 details our approach. Section 5 is dedicated to the application of our method on Moodle 2.4. Section 6 compares Moodle 2.4 and Moodle 2.0 meta-models. Section 7 concludes our paper and presents our perspectives.

2 Meta Models

In recent years, researchers have begun to formalize LMSs instructional languages in order to specify models in conformance with the infrastructure design languages of LMSs.

In an E-learning context, [16] defines three features that a meta-model must have: (1) Limitation of the functionalities consisting in restricting the modeling domain to the web services without global settings like security, (2) Identification of the element factories consisting in identifying element factories and their capacity to set elements which can be used by the web services, and (3) Definition of the factorization mechanism based on the fact that a model is a simplified view of a system. This meta-model enables a team of designers to describe what should be learnt from a scenario, the characteristics of students that will use the scenario (learner models), how the learners will face this knowledge (teaching and available learning strategies), etc.

[17] has proposed a meta-model for adaptive courses that can be easily integrated into e-learning platforms. The meta-model is based on the Felder-Silverman Learning Styles Model (FSLSM) describing a single student in accordance to four dimensions: active & reflexive learning style, sensitive & intuitive learning style, visual & verbal learning style, and sequential & global learning style. Other learners' characteristics like the state of knowledge and the learning goals are not taken into account. For presenting the content of the course, content objects are considered to include the relevant learning materials. Furthermore, [17] incorporates examples as course elements. Examples are used for better illustration and provide students with more concrete material. Moreover, students can check their acquired knowledge by the use of self-assessment tests. Another element includes exercises that serve as practice area where students can try things out or answer questions about interpreting predefined solutions or developing new solutions.

[9] was interested in specifying and designing learning situations supported by PBCL (Project-Based Collaborative Learning). To allow teachers to elaborate a PBCL scenario, they propose a meta-model dedicated to the PBCL. In this approach, teachers can design a learning scenario based on the PBCL meta-model. Then, this scenario is adapted to a chosen platform: a models transformation approach is proposed allowing the integration of PBCL scenarios in a platform. [9] applies his proposal on the Moodle platform.

All these presented works and many others [18] propose a meta-model to formalize LMS instructional language but to our knowledge, there is no proposition that focuses on identifying an explicit process or method to formalize it.

The next section emphasizes on the importance and the utility of defining an explicit method to formalize LMS instructional languages.

3 Context

Many universities have adopted web-based LMSs as the TEL system. They use them to offer teachers a range of pedagogical and administrative tools for supporting teaching and learning activities [19]. However, many teachers have difficulty using LMSs to create learning designs that are truly engaging to their students [20]. They are not familiar with the implicit learning design domains of LMSs [10]. Most of open source LMSs are very difficult to apply in real schools, because teachers are not familiar to using an LMS which needs to take an effort to appropriate it [11].

Due to the complexity of LMS functionalities, users are expected to have some pre-existing knowledge of these functionalities. Despite online forums, it is still difficult for a teacher to design his courses on platforms. LMSs are in continuous evolutions and discussions regarding different versions of a platform are interwoven. In addition, many forums, if not all, have input from developers, programmers, and software architects. That is why forums are difficult environments for non-expert LMSs users to make sense of.

In addition, there is no support (neither human nor software products) able to help teachers in clarifying, defining and then specifying their learning situations before setting them up within the LMS. They have to appropriate the various screens and form-based interfaces to abstract some low-level details to think about their global design courses.

Teachers need solutions to narrow the gap between their educational intention and the pedagogical features proposed by the LMS at their disposal. They ask for appropriate tools helping them in understand the underlying "way of thinking and designing" of this LMS.

In our work, we aim at supporting practitioners to overcome these LMSs' obstacles in order to help them in focusing on the design of learning situations.

Our contribution consists in extracting, identifying, and formalizing the LMS implicit instructional design language. We also on purpose propose a meta-model formalism to capture it. The meta-model is obtained by the abstraction of pedagogical features and services provided by the considered LMS. This meta-model acts, according to the language theory, as an abstract syntax. It will then be used as a basis for the development of external editors [21, 22].

4 The LMS Centred Approach

We propose a method to identify and formalize the instructional language of LMSs. Our approach takes into account a macro-HMI analysis, a functional analysis and a micro-analysis. In this section, we sketch an overview of our approach then we explain in details each step of the method.

4.1 The Identification and the Formalization Process: An Overview

In our work, we focus on pedagogical tasks and functionalities of a specific LMS. Our hypothesis is that LMSs are not pedagogically neutral and they embed an implicit language based on the LMS specific paradigm to specify the design of a learning activity [23]. Our work aims to define the necessary analysis and steps for the identification and formalization of an LMS instructional design language.

The first attempt to define the method was presented in [23]. However, the proposed process did not take into account the presence of common elements between pedagogical activities/resources on LMS. The final meta-model excludes elements that are relevant for instructional design such as activity completion conditions, as well as outcomes and grade conditions.

Our method is specified according to three different viewpoints: a viewpoint centred on macro-HMI, a functional viewpoint and a micro viewpoint.

The first viewpoint consists of HMIs analysis according to two strategies: (1) the analysis of existing situations on the platform and (2) the analysis of interfaces related to the specification of new situations. After the macro-HMI analysis, we factorized the macro-HMI model in order to obtain the simplified macro model. The second viewpoint focuses on the identification of LMS existing functions. The third viewpoint concerns the micro analysis of the LMS instructional design language.

Figure 1 shows the proposed process. It is composed of the macro-HMI analysis, the factorization of HMI-macro model, the functional analysis and the micro analysis. The micro analysis is based on the micro-HMI analysis and technical analysis. The final model results from a confrontation of micro-HMI and technical models.

In the next sections, we present in details different steps of the process.

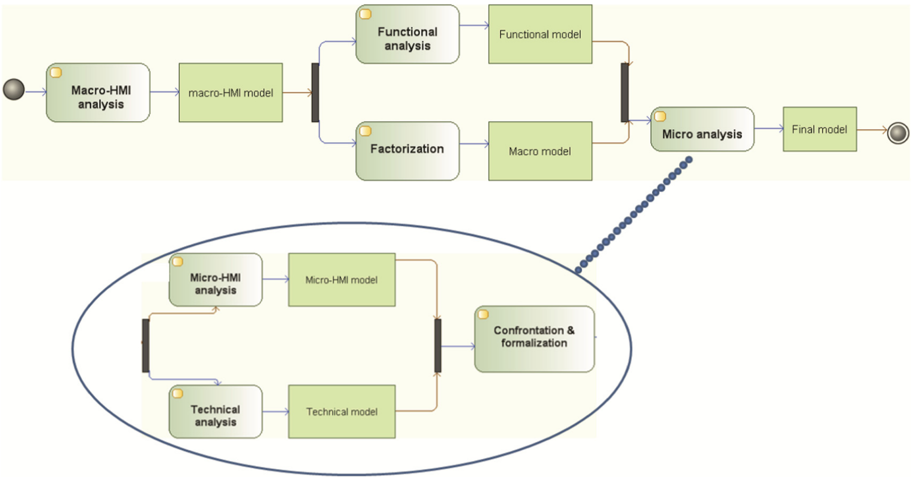

Fig. 1. Analysis process of the instructional design language.

4.2 Macro-HMI Analysis

The macro-HMI analysis consists in identifying platform interfaces related to the Instructional Design (ID).

LMSs are usually composed of many interfaces, developed for different purposes and users' categories. In our work, we have ignored interfaces related to administration and management purposes; we are only interested in interfaces related to instructional design usages. The instructional design language is identified using two methods: the analysis of interfaces titles and the analysis of the navigation paths.

The first analysis step is to choose the main interface. Then, the analysis must determine whether or not the interface provides a pedagogical aspect. Interfaces related to ID are taken into account. The main interface concept is identified and presented on the macro-HMI model. Relations between model concepts are finally identified and defined.

Interfaces identification is an iterative process. When a new interface is identified, the analyst studies existing links inside this interface in order to access to new interfaces. Only Interfaces related to ID are analyzed and added to the macro-HMI model.

The macro-HMI model is presented by the meta-model format. We have chosen the meta-model format because it allows presenting clearly platform elements, their attributes, relations between them and their cardinalities.

4.3 Factorization

Factorization is the process of finding common attributes shared between two or more pedagogical elements (classes) in the macro-HMI model and moving them into an existing or a new abstract parent element. The non-common attributes will not change place. The difference between an abstract class and a concrete class is that a concrete class can be instantiated. The role of an abstract class is that of possessing concrete subclasses. This is important for the factorization of the attributes and common methods realized by the sub-classes. Visually, an abstract class is represented implicitly with a cursive formatting (in italics) of the name of the class (cf. Fig. 2, Activity/Resource class).

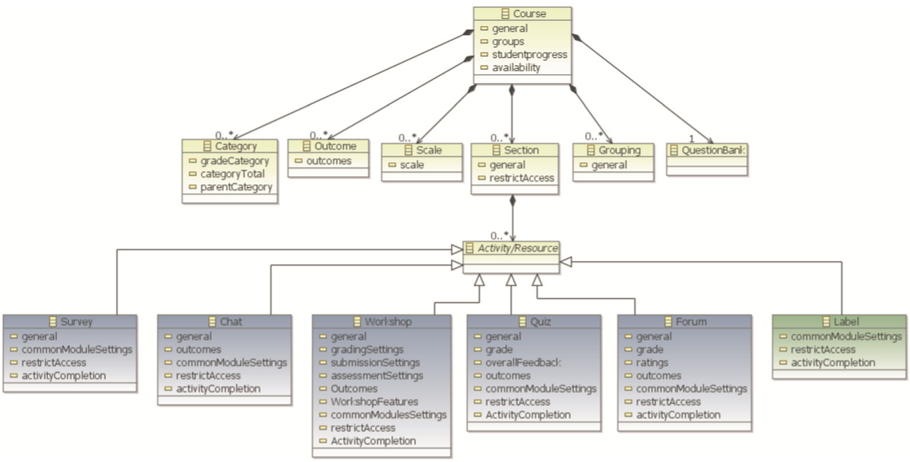

Fig. 2. An extract of Moodle macro-HMI model.

Many works shows the relevance of classes and associations factorization in modelling languages [24]. The factorization we propose is based on the fact that a model is a simplified view of a system. Therefore a model element can factorize the system collection of elements [15].

This step aims to find common elements in pedagogical activities/resources and common relations between them. Factorization is applied on the Macro-HMI model. The macro model, resulting for the factorization, is clearer and more simplified than the Macro-HMI model.

4.4 Functional Analysis

In the software engineering field, a software life-cycle model includes a functional analysis in the requirements and specification phases. Functional requirements are associated with specific functions, tasks or behaviours the system must support. Functional specifications describe what the system must do as well as requested properties of inputs and outputs.

In our context, the functional analysis aims to identify the functionalities dedicated to the course instructional design. The HMIs of the Macro-HMI model are analyzed from both functional and pedagogical perspectives. Administrative perspectives (like display functions, etc.) are rejected from the functional model. The functionalities are implicitly embedded in interfaces via HMI widgets (buttons, links, etc.) facilitating the interactions between users and system. Each widget has to be tested in order to determine its pedagogical features. Then, the analyst has to give a function name for each pedagogical widget. The functional analysis is an interactive process, every time we identify a new function, we must verify its pedagogical use. Only functions with pedagogical use are presented on the model. Sub-functions are also added to the functional model.

4.5 Micro Analysis

The micro analysis is based on the macro and the functional models. It takes into account two different viewpoints: micro-HMI and technical viewpoints. We propose a confrontation of micro-HMI and technical models to formalize the final model.

4.5.1 Micro-IHM Analysis

The micro-HMI analysis consists in analyzing the concerned interfaces at a finer scale. It aims to identify all elements relevant to the instructional design, including their features (attributes, types, etc.). To conduct this analysis, we propose many steps. After choosing an element of the macro model, the analysis concerns the interfaces for realizing/defining a dedicated use case of the functional model. The concerned interface is break down into many areas. Each component of each area (titles of blocks, menus, forms, etc.) has to be analyzed in order to determine its pedagogical features. The analysis concerns also many pedagogical elements which are described by the use of various forms, widgets and software components (buttons, links, etc.). Two main categories of the forms elements/attributes can be identified: required elements and optional elements. The required ones have to be identified because they form the main elements of the LMS instructional design language. The non-setting of these elements prevents the ordinary working of system. These characteristics have to be identified: it presents an important feature about the instructional design language of learning platforms.

4.5.2 Technical Analysis

The second step of the process concerns the technical analysis [23]. Several technical analyses are possible: databases, source code, courses backup/restore, etc. During this step, the main source of information for identifying the instructional design language is the LMS database. The other technical analyses will be used during the confrontation step.

This analysis consists in specifying a reduced Conceptual Data Model from the one available by LMS providers if it exists. In our approach, the database analysis has to be restricted to the tables/columns in relation to instructional design data. The main obstacle is to identify these data. Information from the micro-HMI analysis could be useful to achieve this goal.

This technical analysis consists in (1) looking over all database tables in order to sketch a first draft of the model, (2) focusing on tables embedding elements in relation to instructional design concepts. These tables can be identified through the semantic analysis of their titles or their record fields. Some tables could be identified through their dependencies with others or through the foreign keys. The analysis consists then in specifying the database schema on the basis of the databases reverse engineering rules. The Conceptual Data Model can be finally specified from this schema. This model is relevant to represent the technical-model viewpoint because it hides ill-structured databases, misconceptions or redundancies.

4.5.3 Confrontation and Formalization

The last process step concerns the confrontation of both micro-HMI and technical models, and the formalization of the final model. The micro-HMI and technical models are compared in order to (1) refine the micro-HMI model, (2) detect and correct the difference between models, (3) ensure that the final model can be easily bind to a computer-readable format for the existing LMS.

The confrontation conducts verifications on the definition of the instructional design elements on both models. Some differences or ambiguities (like the definition of similar elements, the non-existence of some attributes, divergences about the types of attributes, etc.) are so identified. They require a deeper and finer analysis of both HMI and technical analysis. At this step, other technical-centred analysis (source code, backup packages, etc.) can be useful. For example the source code analysis consists in directly reviewing the LMS code.

It primarily concerns the code of the HMI definition and the queries for inserting / selecting data. This analysis can reveal many details that developers have chosen to encode for effectiveness or portability reasons. The aim of this process step is to formalize the instructional design language.

5 Application of our Approach on Moodle 2.4

In this section we present the application of our process on an LMS. We have chosen Moodle 2.4 as a use case for many reasons: (1) Moodle is increasingly used in schools, universities and companies, (2) Moodle is also used in our university, and (3) Moodle has an active community who continuously develops APIs that provide tools for its scripts (so once the editor is finalized, we will share it with the community). Note that the version 2.4 is the installed version in our university.

5.1 Application of the Macro-HMI Analysis on Moodle 2.4

The application of macro-HMI analysis on Moodle consists in identifying interfaces related to course design. We analyzed interfaces titles and navigation paths / URLs. We studiously browse all the links in a specific interface. These links often point to new interfaces. Moodle is designed based on a top-down approach: the main interface is about specification and presentation of the course content, other interfaces (like add a forum, a label…) are accessible from the main interface.

The Fig. 2 shows the result of applying the macro-HMI analysis on Moodle. A course is composed of categorie(s), outcome(s), scale(s), section(s), group(s), grouping(s) and one question bank.

Course sections are organized into resources and activities for students. Moodle 2.4 offers 7 resources (Book, Page, Label, IMS content package, File, Folder, and URL) and 13 activities (Forum, Database, Glossary, Assignment, Lesson, Quiz, Workshop, SCORM package, External tool, Choice, Survey, Wiki, and Feedback). In Fig. 2, we present only one resource (Label), and 5 activities (Survey, Chat, Workshop, Quiz, and Forum) for clarity reasons.

In the page specification of each concept, attributes are divided into different parts. For example, for the Chat activity, its fields are divided into 4 parts named: general, common module settings, restrict access, and activity completion. These parts names are presented in the macro-HMI model.

Note that there are only two types of relationships within this model: composition relationship and inheritance relationship.

5.2 Application of the Macro-HMI Analysis on Moodle 2.4

After the macro-HMI analysis, we applied the factorization process. We noticed that all activities/resources had the common attributes: “commonModuleSettings”, “restrictAccess”, and “activityCompletion”. So we moved these attributes to the Activity/Resource class. All activities had the common attribute “general” according to the macro-HMI model, that’s why we created a class called “Activity” and we moved the attribute “general” into it. Some Moodle activities could have outcomes like Chat activity, Workshop, and Quiz. We added in the macro model a class named “ActivityWithOutcomes”. This class had “outcomes” as an attribute. We noticed that some activities with outcomes could be graded. Therefore, we added the class “GradedActivityWithOutcomes”. Among “GradedActivityWithOutcomes” class, some activities had the common attributes “grade”. The “ActivityWithGradedSection” class is created and contained the “grade” attribute. Some activities from the “ActivityWithGradeSection” had the common attributes “ratings”. The class “ActivityWithRatingsSection” is added to the macro model with the attribute “ratings”. All coming steps are carried out on the basis of this analysis.

5.3 Application of the Functional Analysis on Moodle 2.4

Based on the macro-HMI model, we proceeded to the functional analysis on Moodle. We divided each interface to several areas. Then, for each area, we studied the graphical interface components to identify functionalities related to instructional design. For example, from the main interface of a Moodle course, a teacher can show/hide/move a section. He can modify the course description, and manage different groups. He can also add an activity/resource in a specific section. If the teacher adds a forum, he will be pointed to a new page about forum specification. He can add files, add/modify/delete/separate a discussion and also reply to a discussion.

We have grounded the formalism of the functional model on the SADT (Structured Analysis and Design Technique) Model [24]. SADT is a multi language supporting the communication between users and designers. It is based on simple concepts in an easy graphical and textual formalism. This language is conformed to our functional analysis approach: top-down, hierarchical, modular and structured.

This analysis is very important in our process; it can verify existence and relation between macro-HMI elements.

5.4 Application of the Micro Analysis on Moodle 2.4

As explained in Sect. 4.5, the micro analysis consists the micro-HMI analysis, the technical analysis, and the confrontation and formalization process.

5.4.1 Step 1: Micro-IHM Analysis

The application of IHM-micro analysis is about characteristics identification of instructional design elements. It is based on the macro and functional models.

For example, the “Course” class has “general” as attribute. In this phase, we study in details fields with pedagogical use related to this attribute. “Fullname” and “shortname” are these fields, so we replace “general” attribute in the macro-HMI model by “fullname” and “shortname” attributes in the micro-HMI model.

The Fig. 3 shows an extract of Moodle micro-HMI model (without taking into account corrections in red).

Reference relationships appear in this model. For example the abstract class “ActivityWithOutcomes” refers to “Outcome” class: a teacher can define outcomes to a course then he can associate a specific outcome to Moodle activities except for Choice, Survey, Wiki and Feedback activities.

5.4.2 Step 2: Technical Analysis

The technical analysis consists in analyzing the Moodle database. Our goal is to identify the Moodle instruction design language from a technical viewpoint to approve the relevant of specific data for this language.

This analysis consists in specifying the reduced Conceptual Data Model for Moodle in relation with the instruction design. We have reviewed all Moodle database tables. Titles semantic analysis of tables and fields allows to (1) gather the tables related to the

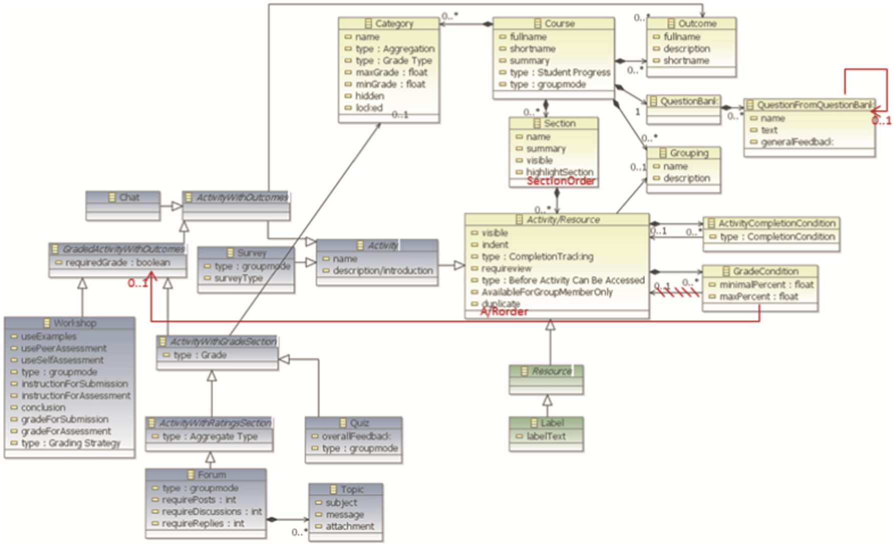

Fig. 3. An extract of Moodle micro-HMI model (without corrections in red), an extract of Moodle final model (with corrections in red).

ID, and (2) ignores those related to technical specifications (users' management, learners' tracking…). Then we studied dependences and relations between database tables. The generated Conceptual Data Model is based on reverse engineering rules. Foreign keys enable the specification of required multiplicities.

In the next section, we present the confrontation and the formalization of the Moodle instructional design language.

5.4.3 Step 3: Confrontation and Formalization

The micro-HMI analysis and the technical analysis have specified two Moodle instructional design models according to two different viewpoints. In this step, we are interested in the confrontation of these models to formalize Moodle instructional design language.

This step is very important in our process. We think that the use of only one analysis method presents many negative points. For example, the micro-HMI model depends directly on the Moodle analyst competence. This means the possibility lack of pedagogical attributes. Similarly, the technical analysis is not an easy task. Many data structures are not explicitly reported when creating the database.

From the 2 models comparison, we notice that every element/ attribute existing in the micro-HMI model is certainly presented in the technical model. But some elements exist in the technical model without being present in the micro-HMI model. That is why we refer to the PHP source code analysis of Moodle to verify the presence of these elements.

Figure 3 (including corrections in red) shows an extract of Moodle final model. Corrections in red present the confrontation result of the two models. For example thanks to the technical analysis, we found that every section has an order. This attribute has not been detected by the micro-HMI model. The code source analysis confirms the presence of this attribute. The attribute “SectionOrder” is presented in the final HMI model.

The confrontation phase allows also rectifying information on the micro-HMI model. Figure 4 shows an example about relationship verification between the “GradeCondition” class and the “Activity/Resource” class.

Fig. 4. An example about relationship verification between the “GradeCondition” class and the “Activity/Resource” class.

Based on the micro-HMI analysis, the “GradeCondition” class refers to the abstract class “Activity/Resource” while the same class refers to a graded activity in the technical model. The code source analysis of Moodle conditionlib.php file confirms that the grade condition refers to a graded activity. That is why the reference relationship is between the two classes “GradeCondition” and “GradedActivityWithOutcomes” in the final model. The final model resulting from the confrontation phase formalizes the Moodle instructional design language.

6 Comparison Between Moodle 2.0 and Moodle 2.4 Meta-Models

In this section, we apply our identifying and formalizing approach on Moodle 2.0 then we compare the two meta-models (Moodle 2.0 and 2.4) in order to identify differences between these versions. Figure 5 (including corrections in red) shows an extract of the Moodle 2.0 final model. Table 1 presents the differences between the two meta-models process by being capable of identifying the new functionalities added by Moodle 2.4 developers in comparison to Moodle 2.0 (The whole Moodle’s meta-models are available at the following link: http://www-lium.univ-lemans.fr/~laforcad/graphit/wp-content/uploads/2015/02/metamodels.pdf).

Table 1. Difference between Moodle 2.4 and Moodle 2.0 meta-models.

	Moodle 2.4	Moodle 2.0	Comments
External Tool class	Yes	No	The external tool activity module enables students to interact with learning resources and activities on other web sites
Book class	Yes	No	The book module enables a teacher to create a multi-page resource in a book-like format, with chapters and subchapters
Relation between Section & ActivityCompletionCondition classes	Yes	No	This relation determines any activity completion conditions which must be met in order to access the section
Relation between Section and GradeCondition classes	Yes	No	This relation determines any grade conditions which must be met in order to access the activity
Assignment class	Yes	Yes	In Moodle 2.4 we have 1 class for assignment (Assignment) while in Moodle 2.0 we have 4 classes for assignment (Online text, Advanced uploading files, Offline activity and Upload single file)
blindMarking attribute for Assignment class	Yes	No	Blind marking hides the identity of students to markers
gradingMethodAssignment attribute for Assignment class	Yes	No	This attribute defines the advanced grading method (Simple direct grading, Marking guide, Rubric) used for calculating grades in the assignment
Relation between Assignment and Grouping classes	Yes	No	Students are able to collaborate on an assignment

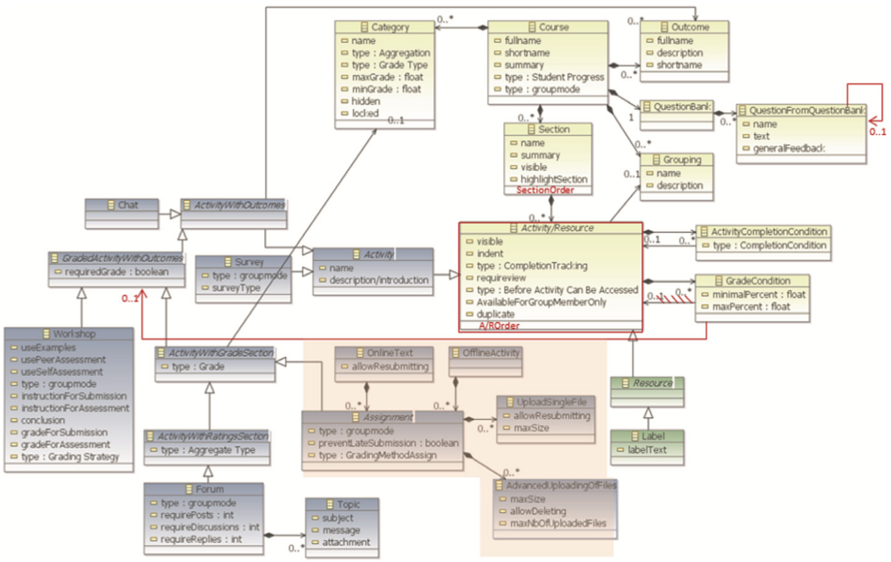

Fig. 5. An extract of the Moodle micro-HMI model/ the Moodle 2.0 final model (without/with corrections in red).

This process is dedicated to LMSs active communities and more specifically to designers with a competence in IT and the service of information technology and communication for education (pedagogical engineers) who meets difficulties in appropriating the instructional design language of LMSs.

7 Conclusion

In this paper is dedicated for teachers-designers using Learning Management Systems within their academic organizations. Nowadays Learning Management Systems like Moodle are Widespread within academic organizations, they are not limited to distant courses, and they Provide many tools and services to teachers-designers. But teachers have many problems related to their uses. In fact, teachers are trained on how to use an LMS but not how to design learning situations on it. In addition, Teachers must abstract instruction design from technical/administrative details. Our work aims at exploiting the LMS implicit language in order to allow the elaboration of some external, well suited and dedicated authoring tools. To this aim, we identify and formalize the LMS implicit instructional design language. In this paper, we present techniques for specifying meta-models both based on the LMS semantics and directed towards the practitioners' one. We apply these techniques on two versions of the Moodle platform: 2.4 and 2.0. These meta models allows to provide teachers-designers with some graphical Visual Instructional Design Languages, and their dedicated editors, taking into account their practices and needs, while ensuring that produced models will be operationalized without major semantics losses into the targeted LMS.

Based on meta-models, we will originally develop VIDLs on top of the LMS internal language in order to insure the binding issue and the semantics mapping. By only extending LMS with a dedicated communication API, binding issues will be addressed. We will propose then to target teachers-designers instructional design needs and practices, capturing into analysis & design patterns, by developing VIDLs designed on top of the LMSs languages by some Model-Driven Engineering and Domain-Specific Modelling techniques and tools.

Our research work allows teachers-designers community to design their entire courses, outside platforms, basing on their pedagogical needs without technical difficulties. Our approach promotes the use of all LMS activities and resources and expands LMS pedagogical concepts not by adding new concepts to users but by facilitating and clarifying the existing tools thanks to the external editor. It can confirm that every LMS is not pedagogically neutral but embeds an implicit instructional design language relying on specific paradigms and educative theories followed by the LMS providers.

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References

1. Tchounikine, P., Morch, A., Bannon, L.: A computer science perspective on technology-enhanced learning, pp. 275–288. Springer, The Netherlands (2009)
2. Berger, C., Kam, R.: Definitions of instructional design (1996). http://www.umich.edu/~ed626/define.html
3. Gimenes, I.; Barroca, L.; Barbosa, E., Júnior, Oliveira, E.A.: Learning design in software engineering courses. In: International Conference on Computer Supported Education, CSEDU 2014, 1-3 April 2014, Barcelona (2014)
4. Szabo, M., Flesher, K.: CMI Theory and Practice: Historical Roots of Learning Managment Systems. Paper presented at the E-Learn 2002 World Conference on E-Learning in Corporate, Government, Healthcare, Higher Education, Montreal, Canada, pp. 929–936 (2002)
5. Jovanovic, J., Gasevic, D., Brooks, C., Devedzic, V., Hatala, M.: LOCO-analyst: a tool for raising teachers' awareness in online learning environments. In: The 2nd European Conference on Technology Enhanced Learning, Crete, Greece, pp. 112–126 (2007)
6. Graham, C.J.: Blended learning systems: definitions, current trends and future directions. In: Bonk, C.J., Graham, C.R. (eds.) Handbook of Blended Learning: Global Perspectives, Local Designs, pp. 3-21. Pfeiffer Publishing, San Francisco, CA (2005)
7. Brito, I.S., Tavares, M., Rodrigues, E.: Using ICT to support e-Learning in higher education. In: Proceedings of the 6th International Conference on Computer Supported Education. CSEDU 2014, Barcelona, Spain (2014)
8. Oubahssi, L., Laforcade, P., Cottier, P.: Re-engineering of the apprenticeship elec-tronic booklet: adaptation to new users requirements. In: The 10th IEEE International Conference on Advanced Learning Technologies, Sousse, Tunisia, pp. 511–515, July 2010
9. Abdallah, F., Toffolon, C., Warin, B.: Models transformation to implement a Project- Based Collaborative Learning (PBCL) scenario: Moodle case study, pp. 639–643. Santander, Cantabria, Spain, IEEE-ICALT (2008)

10. Martinez-Ortiz, I., Sierra, J.L., Fernández-Manjón, B.: Enhancing IMS LD units of learning comprehension. In: The 4th International Conference on Internet and Web Applications and Services, Venice, Italy, pp. 561–566, May 2009
11. Mekpiroona, O., Tammarattananonta, P., Buasrounga, N., Apitiwongmanita, N., Pravalpruka, B., Supnithia, T.: SCORM in open source LMS: a case study of LEARNSQUARE. In: ICCE2008, Taipei, Taiwan, pp. 166–170 (2008)
12. De Vries, F., Tattersall, C., Koper, R.: Future developments of IMS Learning Design tooling. Educ. Technol. Soc. **9**(1), 9–12 (2006)
13. Baggetun, R., Rusman, E., Poggi, C.: Design Patterns for collaborative learning: from practice to theory and back. In: Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications, AACE 2004, Chesapeake, VA, pp. 2493–2498 (2004)
14. Alario-Hoyos, C., Bote-Lorenzo, M.L., Gómez-Sánchez, E., Asensio-Pérez, J.I., Vega-Gorgojo, G., Ruiz-Calleja, A.: GLUE!: An Architecture for the Integration of External Tools in Virtual Learning Environments. Comput. Educ. **60**(1), 122–137 (2013)
15. Al-Ajlan, A., Zedan, H.: E-learning (Moodle) based on service oriented architecture. In: Proceedings of the EADTU's 20th Anniversary Conference, Lisbon, Portugal, 8-9 November, Lisbon-Portugal, pp. 62–70, vol. 1 (2007)
16. Caron P.-A., Derycke A., Le Pallec X.: The bricoles project: support socially informed design of learning environment. In: 12th International Conference on Artificial Intelligence in Education (AIED 2005), pp. 759–761. IOS Press, Amsterdam (2005)
17. Graf. S.: Adaptivity in learning management systems focusing on learning styles. PhD thesis, Vienna University of Technology (2007)
18. Drira, R., Laroussi, M., Le Pallec, X., Warin, B.: Contextualizing Learning Scenarios According to Different Learning Management Systems. TLT **5**(3), 213–225 (2012)
19. Coates, H., James, R., Baldwin, G.: A critical examination of the effects of learning management systems on university teaching and learning. Tert. Educ. Manag. **11**, 19–36 (2005)
20. Steel, C.: Reconciling university teacher beliefs to create learning designs for LMS environments. The University of Queensland. Australas. J. Educ. Technol. (AJET2009) **25**(3), 399–420 (2009)
21. Loiseau, E., Laforcade, P.: Specification of learning management system-centred graphical instructional design languages - A DSM experimentation about the Moodle platform. In: ICSOFT'13, Reykjavik, Iceland, pp. 29–31 (2013)
22. Laforcade, P., Abedmouleh, A.: Improving the design of courses thanks to graphical and external dedicated languages: a moodle experimentation. In: Moodle Research Conference 2012, Heraklion, Greece, 14-15 septembre 2012, pp. 94–101 (2012)
23. Abedmouleh, A., Oubahssi, L., Laforcade, P., Choquet, C.: Expressing the implicit instructional design language embedded in an LMS: motivations and process. In: Computers and Advanced Technology in Education, Naples, Italie, Juin 2012
24. Dao, M., Huchard, M., Rouane Hacene, M., Roume, C., Valtchev, P.: Improving generalization level in UML models iterative cross generalization in practice. In: 12th International Conference on Conceptual Structures, ICCS'04, Huntsville, USA, pp. 346–360 (2004)

APLe: Agents for Personalized Learning in Distance Learning

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Abstract. This work presents an intelligent tutoring system that supports personalized learning especially in a distance learning setting. The proposed architecture is based on multi-agents which facilitate the communication between the different components and on ontologies that provide a sound and complete representation of the knowledge domain. The operational procedure of the multi-agent system is described and the overall functions of its fundamental components are illustrated. The prototype, called APLe, provides dynamic learning path sequencing in a bottom up fashion using direct information about the student preferences or learning styles and relative information about the student learning process as part of a group. The preliminary evaluation of our system indicated positive feedback by the users in terms of the usability of the system, completeness of the educational content and ability of the system to adapt to the individual's educational needs and preferences and informed for further developments required.

Keywords: Agent-based systems · Intelligent tutoring systems · Ontologies · Personalized learning · Distance learning · Dynamic courseware generation

1 Introduction

The term Intelligent Tutoring Systems (ITSs) refers to complex tutoring systems that can be adapted to the needs, characteristics and learning progress of the individual learner [1]. These systems exploit a large amount of educational knowledge and usually they employ pedagogical methodologies. Especially in the case of agent-based architectures, the interaction between the different components of the ITS is achieved through the communication of the intelligent agents assigned to each component. A typical architecture of an ITS consists of four models: (a) the domain model which contains all the knowledge and problem-solving strategies to be learned, (b) the student model which is an overlay of the domain model; it is the core component of an ITS and stores all the data about student's characteristics and progress, (c) the tutoring (or pedagogical) model which contains all the information

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about the various pedagogical decisions and methodologies and (d) the user interface (UI) which enables the communication between the user and the system [2].

In this work we introduce a pilot educational system, called APLe, which enhances personalized learning of students in the context of selected courses. We propose an agent-based intelligent tutoring system, able to adapt to student's characteristics by employing learning tactics based on the student's learning profile and progress. More specifically, our proposed multi-agent system architecture employs a set of homogeneous student-dedicated tutor agents for each course. Each agent builds an internal learning model based on the domain and available resource semantic representation while during the educational process the agent updates the model based either on the student's learning profile and interaction or by accessing the student's progress with respect to a given group. The tutoring system is not domain specific while the pedagogical module is versatile, allowing tutors to experiment on different learning tactics in order to engineer more domain-specific or student profile-oriented agents. Finally, the system self organizes student groups based on overall group progress indicators and without any tutor interference. To the best of our knowledge, this is the first indirect approach towards self-organized learning.

In the context of our work we have chosen to model the main components of the proposed system through ontologies. Ontologies have been widely used especially in the field of education and specifically in tutoring systems for three main reasons: (i) to support the formal representation of abstract concepts and the relations between them in a reusable and extendable way, (ii) to allow the extraction of new knowledge by applying inference mechanisms and (iii) to provide rich semantics for humans to work with and the formalism for computers to perform mechanical processing. Furthermore, ontologies facilitate the reuse and the integration of services and thus e-learning systems are able to provide better applications [3].

Agent technology is a well-accepted approach to address the challenges of technology enhanced learning. In our case, by using intelligent agents in a distance education system it is possible to obtain adaptivity to each individual student's learning capabilities, particularities and learning progress.

The proposed tutoring system follows a 3-tier architectural style. In the presentation tier users connect to the system through a web interface; the logic tier consists of a multi-agent system; agents connect with a semantic repository in order to access the domain related reusable learning objects and student profiles (data tier). The multi agent system is implemented using the Java Agent Development Framework (JADE), a middleware for the development and execution of peer to peer applications following the agent-based development paradigm [4].

The system has been designed in the context of the Hellenic Open University (HOU). HOU has a mission to offer university level education using distance learning methodology and to develop the appropriate material and teaching methods. Currently, HOU offers 31 undergraduate and postgraduate Study Programs with a total of approximately 30,000 students, coached by 1,700 tutors in 1,550 groups (20 students per group on average). Students of the HOU usually live in disparate locations all over the country. Besides being students they usually have families and working obligations so they have pressing time constraints for studying. Given the special characteristics of an adult distance learning education system, the provision of tools, such as the one presented here, that can facilitate the learning process and enhance the learning experience are of great importance.

The rest of the text is structured as follows. In Sect. 2 we elaborate on the ontological models we have implemented in order to represent the learners and generally the knowledge of the domain to be taught. Section 3 presents our agent-based ITS architecture focusing on the tutor agent organization and logic. A detailed system usage example is provided in order to demonstrate system's functionality. The next section provides a preliminary evaluation of our current accomplishments. The advantages of the proposed approach are laid out, especially in the setting of a distance learning education system and future directions of work for its improvement are discussed. Section 5 provides related work on agent-based e-learning systems. Finally our conclusions are given.

2 Ontologies

Ontologies are used for modelling the learners and the knowledge of the learning domain. In order to develop the ontologies we have followed a widely-adopted methodology, described in [5] and for their representation we adopted the Web Ontology Language (OWL) [6]. The implementation process was done by the Protégé tool which is the most widely used and offers a complete development environment. Below we give a more detailed description of the ontological models we have implemented.

2.1 Learner Model

In order to implement the learner model we were based, on the one hand, on student modelling standards [7, 8] and, on the other, on empirical studies that were conducted by social scientists among students of HOU. The proposed learner model is thus a combination of stereotype and overlay techniques. A fully stereotype-based profile, as the information derived from student's descriptions or questionnaires is not accurate for every knowledge domain and the system would adapt to student's needs very slowly. Dynamic attributes related to the learning process are represented with an overlay model. From the empirical studies we extracted information about the dimensions/characteristics of the learner profile that could affect his/her academic performance. A few examples of these dimensions are: the learning style, previous experience, reasons for education, computer literacy, etc. The values for these attributes (i.e. stereotypes) are used for the initialization of the learner's profile and then, after the initialization phase the profile is dynamically modified as the overlay model is updated through the interaction of the user with the system. Table 1 shows the stereotypic profiles we have used and their corresponding values.

The proposed student model is partially based on the standards we mentioned above, but they also have limitations as they reflect different perspectives on the attributes of a learner (e.g. classic CV notion based or student's performance as the most important information). On the other hand, as resulted from the study of other similar student models, there is no approach that satisfies all the attributes of an adult learner within a distance learning environment.

Table 1. Stereotypic profiles and their corresponding values.

Dimensions	Values
Learning style	visual – auditory – read/write – kinesthetic
Use of technology	adaptable – adaptive
Computer literacy	novice – beginner – advanced
Previous experience	novice – beginner – advanced
Time for study	no time – little – much
Reasons for education	career development –career change – general knowledge
Academic literacy	poor – good – excellent
Socialization style	social – solitary

The learner's model: (1) is a dynamic model that can change over time as the system collects information about the user, (2) is a long-term model that keeps generalized information about the user and not only for the current interaction with the system and (3) combines "active" and "passive" user modelling techniques, i.e. in the beginning user provides direct information about him/her and then the system collects data indirectly. The proposed ontology defines the following four upper level classes: (a) `Student` which represents any student, (b) `StudentCourseInformation` which holds information about learner's academic performance during the entire educational process, (c) `StudentCurrentActivity` which captures learner's activity for the current academic year and (d) `StudentPersonalInformation` which is the most compact class of the proposed ontology, representing not only learner's static data, such as demographics, but also more complex characteristics that concern his/her interaction with the system. Table 2 lists the subclasses that exist under the upper level class `StudentPersonalInformation`. The table gives also a brief description of the entities that are represented by these classes. Figure 1 depicts the student model ontology, as displayed in Protégé.

Learning Style. The VARK model [9] argues that for practical reasons, the processing of information is done through the senses. The model describes how human senses are being used for knowledge and skills acquisition. Defines the following four categories of learners: (a) Visual, (b) Auditory, (c) Read/Write and (d) Kinesthetic.

We have chosen to use the VARK model in order to categorize learners by their learning style for two main reasons: (1) there is already in the official website of VARK a scored questionnaire that can help individuals to identify their learning style and (2) the different learning styles can be directly linked with the metadata of the learning objects as we have defined them (e.g. the file format of the object – video, document, audio, etc.).

In order to keep a track of student's interaction with our ITS (learning outcomes achieved, learning objects viewed, evaluation of the learning objects) we have

Table 2. Description of the `StudentPersonalInformation` class.

Class name	Class description
`Accessibility`	The overall set of features that characterizes the student's behavior during his interaction with the e-learning system.
`Disabilities`	The set of student's disabilities that could affects the educational process.
`DemographicData`	Student's static demographic information
`InteractionPreferences`	Student's preferences regarding interaction with the e-learning system
`MediaPresentation`	Student's preferences regarding the presentation of learning objects
`Language`	Student's preferences regarding the language of the learning objects
`LanguageSpoken`	Student's native languages
`LanguagePreferred`	Language that the student prefers for the presentation of learning objects
`Aesthetics`	Aesthetic factors such as the use of highly interactive sensory and visual communication
`Color`	Student's preferences regarding the coloring scheme of learning system's environment
`Fonts`	Student's preferences regarding the fonts used by the learning system's environment
`LearningStyle`	Student's learning style - This class is further divided to the sub classes according to the VARK model
`MotivationState`	Student's motivation during the educational process
`LearningGoals`	Overall goals set by the student
`ReasonsForEducation`	The reasons why the student desires to engage in the educational process
`AcademicLiteracy`	Student's previous formal educational experiences
`Interests`	Student's interests
`TimeStudy`	The average time per day that the student can use for studying

introduced the following classes: (a) `_Course` which is the class where are included the courses attended by the student, (b) `_LORecord`, which keeps all the records for the relations between a user and a particular learning outcome, (c) `_LearningTrack` which represents a low level tracking during the learning procedure. It is connected to a course, a student and a `_LORecord`, with a student, (d) `_StudentLMap` which keeps all the learning paths of the users.

Furthermore, datatype properties, that link individuals to data values, have been set in order to define more effectively the classes. In the proposed model the stereotypic profiles (Table 1) have been expressed as datatype properties.

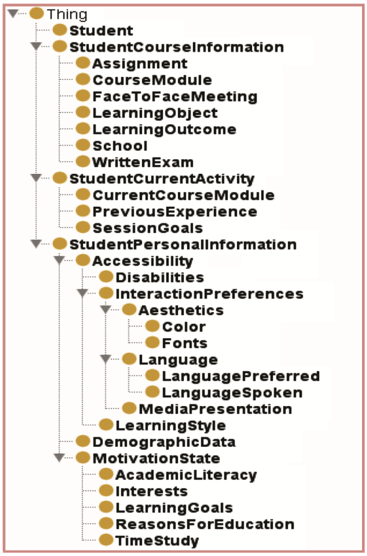

Fig. 1. The student model ontology as displayed in Protégé.

2.2 Learning Objects and Outcomes

In order to represent the domain knowledge we have used the notion of Learning Objects. A learning object (LO) is defined as "a self-contained and independent unit of digital educational content, which is associated with one or more learning objectives and it has as primary aim the ability of reuse in different educational contexts" [10]. The ontological representation and description of LOs has been based on the metadata schema proposed in [11].

The system also needs to keep a record of the learner's performance. To achieve that, we have used the notion of Learning Outcomes. According to the Bologna project [12] a learning outcome is a statement of "*what a learner is expected to know, understand and be able to demonstrate after completion of a learning process (a lecture, a module or an entire program), which are defined in terms of knowledge, skills and competence*". For the classification of the learning outcomes in different level skills we have applied the Revised Bloom's taxonomy [13], as it is the most widely used. The detailed description of the ontological representation for the learning outcomes is given in [14].

It is worth noting here that the process for the cognitive domain representation from which we construct the corresponding learning objects and also the definition of the learning outcomes for the different cognitive domains is realized within a well-defined and applied collaborative methodology between domain experts (tutors) and knowledge engineers, described in [15, 16].

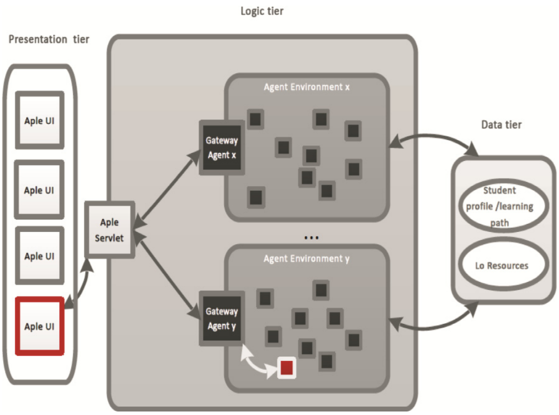

Fig. 2. System architecture.

3 Agent-Based Platform

3.1 System Architecture Overview

In this section, we provide an overview of the ITS prototype, called APLe (Agents for Personalized Learning), whose system architecture is depicted in Fig. 2. Students interact with the platform through a web based interface; a servlet keeps track of all available Gateway Agents (GA) and acts as dispatcher in order to route each student request/action to the proper GA, based on user and selected course information. GAs are customized JADE gateway wrapper agents that interface between agents of a remote agent environment and the servlet. GAs maintain and utilize student to Tutor Agent (TA) mappings in order to transfer request/action messages between students and corresponding agents (inside their particular agent environment). In Fig. 2 two such environments are depicted representing two different courses (e.g. Structured Programming in C and Software Engineering). For different students attending this course the system will spawn different TAs; with red color we depict a student UI-TA mapping example.

In case a GA has no mapping for a particular user (e.g. on user login), it creates a TA. Then, requests/actions are transformed into specific data structures (we refer to these as Blackboard Beans or simply beans) which encapsulate request/action specific information such as session id, user id, course, action type and action data. GAs are triggered either by asynchronous incoming beans or FIPA ACL [17] compliant messages via a cyclic ACL message tracking behavior. If the agent receives a bean, the agent translates the data into an ACL message which is transmitted to the corresponding agent. On the opposite, when the agent receives an ACL message from a TA then the agent (a) finds the corresponding bean, (b) attaches the agent action/response data to the bean and (c) sends the bean back to the servlet. In some edge cases such as the termination of a TA or some user actions irrelevant to the TA's tutoring process, the GA responds directly by populating the bean with the corresponding information. The GA processing algorithm is depicted in Fig. 3.

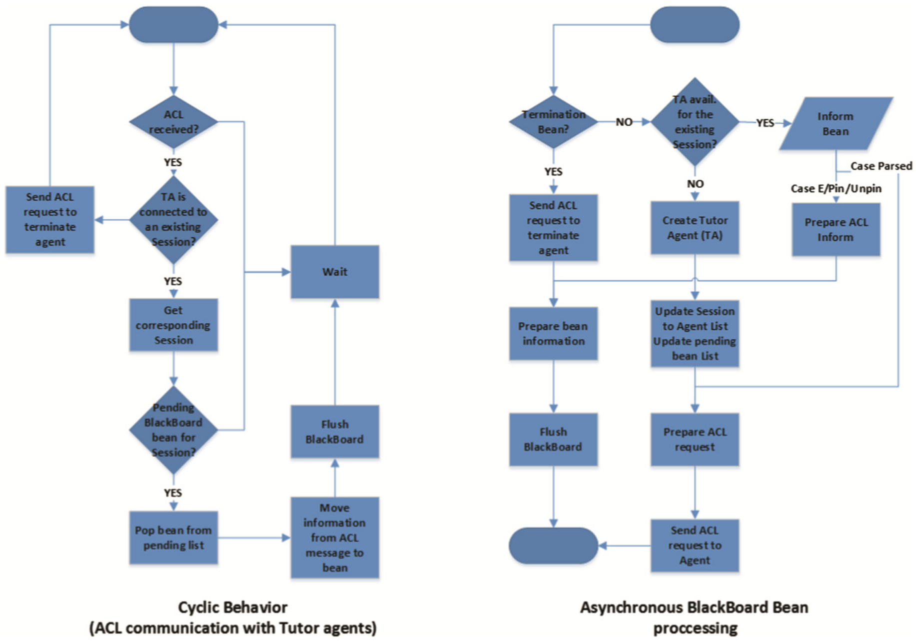

Fig. 3. Gateway Agent processing for incoming ACL messages and Blackboard Beans.

TAs and GAs are grouped inside a set of agent environments (JADE containers) which can be distributed in different physical places of the service provider infrastructure. Each agent environment contains at least one GA which is created on system startup. On the other hand, TAs are generated and terminated dynamically.

Although this approach introduces some extra communication overhead (there exist user actions/requests that do not affect the learning process and thus could be handled in a central fashion), we argue on transferring the information load to a dedicated tutor agent for scalability, error tolerance, robustness and security reasons. No matter of system traffic, the servlet and GAs do not consume resources on data processing while the communication with the repositories is minimal and exposed through a lightweight API which is limited on credential, logging, student and course general information. If for some reason some TAs fail, these agents are terminated while the system continues to operate for other connected users. If for some reason the session with the student terminates, the corresponding Tutor Agent is terminated as well. Moreover, in order to deal better with any occurring bottleneck delay, multiple gateway agents may exist in each agent environment; finally, JADE agent mobility can be applied to allocate agents in more remote containers in respect of a particular grouping policy, e.g. container traffic. The current implementation employs a simple agent grouping policy: TA grouping/placement is applied in regard of the course that is currently attended while each group (environment) contains exactly one GA.

The data tier consists of a semantic repository and a content repository. The content repository is a data storage facility for the available educational content that is available for presentation. The semantic repository contains semantic representation and instances for the students (student profile and action log), Learning Objects, Learning Outcomes and finally the Domain concepts for each available course. As a semantic repository, we use OWLIM-Lite, a high-performance semantic repository implemented in Java and packaged as a Storage and Inference Layer (SAIL) for the Sesame openRDF framework [18]. Each TA is able to interact with the semantic repository through the respective OWLIM-Lite by using a set of predefined SPARQL query and update patterns. Each pattern is defined in respect of the structural and relational properties of the ontologies used for the semantic representation.

3.2 Tutor Agent

Each Tutor Agent is allocated to a student that attends a particular course at the current point of time. The Tutor Agent (TA) architecture consists of two modules, as depicted in Fig. 4: Learning Space Management (LSM), reflecting the internal representation and Learning Tactic Control (LTC), reflecting the learning tactic decision. Sesame refers to persistence/metadata, whereas Learning Procedure Updates refer to the user feedback.

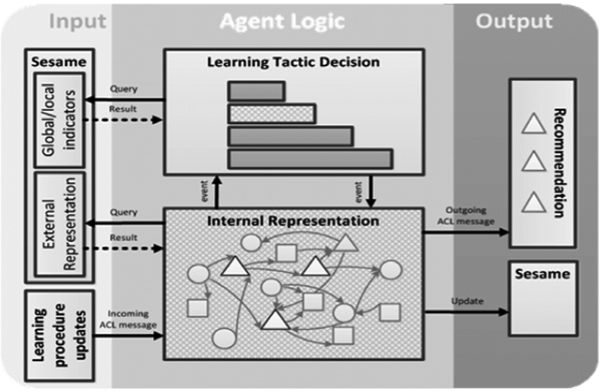

Fig. 4. Tutor Agent architectural design.

LSM is triggered either when the agent receives a learning request/action message either on an LTC-generated internal event. LTC may be triggered in a three way fashion: periodically, on message arrival or on LSM-generated internal event.

Taking under consideration the agent architecture, courseware generation is affected not only as a result to a student's learning events but also in accordance to the relative distance between the student's indicators and the group's indicators. According to this, the TA reacts to direct and indirect stimuli:

- *Direct Stimuli* refer to student learning events (or student learning event chains) which affect directly the node state set of the learning space. The agent reacts to the state change by guiding the student towards a set of (most fitted) learning outcomes. The set is produced after applying the dominant learning tactic to the personal learning space.

- *Indirect Stimuli* refer to indirect interaction between students through specific learning indicators which are estimated globally during the progress of the group of agents for a particular course. The agent reacts (through LTC) to indicator changes by switching the (most fitted) learning tactic.

Learning Space Management. This module creates and operates upon a complex graph structure which represents the personal learning map of a student. The learning space is modeled as a 3-color graph using a variety of links based on explicit/implicit properties which are extracted from the combined educational ontology. The agent is able to generate the learning space using a (Learning Outcome – oriented) algorithm. According to this, an initial (disconnected) graph of learning outcomes is obtained from the educational plan. Next, a recursive series of queries is applied towards the combined ontology according to a breadth first strategy, populating and connecting the initial graph with links. Each link type represents a relation which is inferred from the original ontology using a set of predefined queries. The link set is created in regard to the learning tactic set described in the next section. The advantages on using the particular learning space construction algorithm are: (a) flexibility to create a vast variety of different complexes, based on the original set of goals, the set of well-defined links between learning goals and finally the depth of each link; (b) the algorithm can apply for any connection link between learning outcomes, as far as the link is feasible, based on the available query set. On the other hand, the authors recognize two issues that must be dealt with: a) due to the heavy time complexity, the algorithm may be unpractical if applied by each (computationally limited) agent. Instead, it is recommended for each agent to get an offline version instead of creating it; (b) Agent memory capacity bounds the actual size of the learning space; (c) Finally, the algorithm is not computationally optimal due to its generic purpose. If computational resources are limited and the relation set is predefined, it is then highly recommended to optimize the algorithm by taking advantage of particular structural and relational properties of the ontologies.

Each node is described by its type, current state and current value. The state of each node is determined according to the state of its connections. For that purpose, a set of well defined, non-recursive, non-overlapping transition rules are applied on initialization or after an educational update (incoming message). There are two types of rules: *reactive* and *chain transition* rules. A reactive rule describes a state transition based on a particular learning event related with a particular node (e.g. the user confirmed to have read a learning object thus meaning a state transition of the learning object node from *unknown* to *studied*). A chain transition rule is applied in the direct vicinity of a node which has an updated state. A chain transition rule describes a particular node state transition (current state to a new state) based on quantitative criteria that apply on the neighbor node states (e.g. the former node state change of the learning object node may trigger a state change to all neighbor learning outcome nodes). The current version of APLe uses a simple transition model, described in Fig. 5. Learning Objects have two states (*unknown*, *studied*), Concepts have two states (*unvisited*, *visited*) and Learning Outcomes have four states (*unvisited*, *parsed*, *covered* and *finished*). Only a single reactive transition rule exists to update the Learning Object state while every other transition is triggered in chain reaction if the quantitative criteria are satisfied. As an example, when a new learning object is studied, then (a) all connected Concepts with status *unvisited* will become *visited* recursively; (b) all connected Learning Outcomes with status *unvisited* will become *parsed* recursively; (c) for the set of all the Learning outcomes updated or Learning Outcomes connected to the updated Concepts, the transition rule will evaluate (and trigger) recursively; (d) for each node on the set of Learning outcomes with state *covered* connected to the initial Learning Object or having an updated state *covered* the transition rules will evaluate (and trigger if satisfied).

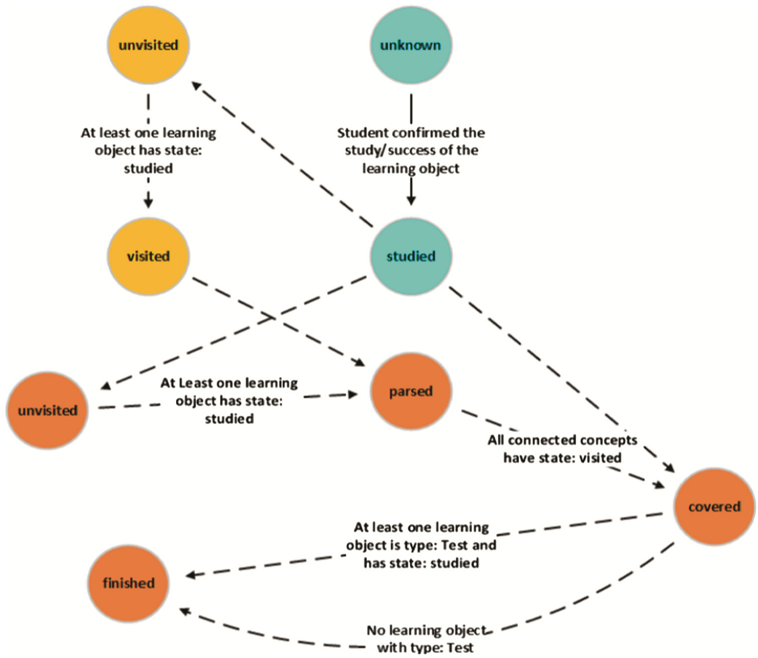

Fig. 5. Transition model supporting chain transition rules in APLe.

The LSM module is able to parse the graph and extract filtered information based on a particular learning tactic and the student profile. The outcome may be either high level (objective) recommendation (based on the learning tactic) or low level (learning object) recommendation based on a student-selected objective and the student profile. Finally, the module updates the ontology repository (the student profile in particular) upon each update.

Learning Tactics Control. In educational context, a learning tactic is the way a student is attempting to learn something [19]. We define an agent learning tactic as the way an agent selects the next Learning Outcome for a student to learn (to persist). More specifically, a learning tactic is a set of connection types and corresponding weights that apply to each node based on the status of its very local neighborhood (directly connected nodes).

The Learning Tactic Control (LTC) is a reactive selection mechanism which uses global and local (internal) indicator updates in order to select one learning tactic to apply to LSM. Each time the LTC is triggered, a series of queries is sent to the ontology repository concerning some quantitative data about the class (or group of students). Next, using a formula that is solely based on indicator data, the available learning tactics are hierarchically checked to take the control of the LSM. The hierarchical winner-takes-all mechanism is based on Brook's subsumption architecture [20] which specifies that when triggered, top level behaviours (in our case, learning tactics) suppress lower level behaviours from triggering. When the dominant learning tactic switches, LTC triggers an internal event which forces LSM to comply with the dominant learning tactic by resetting the connection weights of the learning graph according to the new learning tactic. The result of this action is a rebalanced learning graph.

3.3 System Usage Example

In this section we describe the execution phase of the tutoring system each time a student connects to the system, based on the following assumptions: a tutor of the "*Structured programming in C*" course, has created an initial learning plan of a single learning goal (objective): "*PA_PLI10_46_*". For that purpose, we employ the educational ontology discussed in Sect. 3, consisting of Learning Outcomes, Learning Objects, the Bloom taxonomy schema, an educational domain schema and finally a student profile schema. More particularly, the combined ontology contains 124 classes, 55 object property types, 45 data property types and 737 individuals, including 109 Learning Outcomes, 128 Learning Objects and 208 C programming specific Learning Concepts. A Learning Outcome has a natural language description, an assigned Bloom level, a number of connections with relative Concepts and a number of connections with relative Learning Objects. For example, "*PA_PLI10_46_*" refers to "*combining operators and operands in a program to form expressions*", it is related with C concepts like "*operator*", "*operand*" and "*expression*" and it is satisfied with Learning Object "*MA_PLI_25*". The latter is titled "*Common mistakes on using operators*" related with Concepts "*operator*" and "*operand*", it refers to a document-formatted example (resource type). The "*operator*" concept is connected with parent concepts like "*expression*" and a number of child concepts like "*Logical Operator*", "*Bitwise Operator*" and "*Numeric Operator*".

Also, we consider a set of two learning tactics: a) a *rapid-advance strategy* which focuses on selecting learning objectives towards higher goals as far as at least one sub-objective is fulfilled and b) a *greedy strategy* which focuses on achieving all sub-objectives before moving toward a higher goal. The first learning tactic is triggered by using two indicator sets: student versus mean class quantity of learning goals achieved multiplied by the mean class versus student self-evaluation score. The latter tactic is triggered by using a formula of two indicators: student quantity versus mean class quantity for the successful learning objectives. Also, the rapid advance learning tactic suppresses the greedy tactic.

When a student connects to the course, a Tutor Agent spawns inside the multi agent "*Structured Programming in C*" container; next, the agent initializes the learning space using the initial set of objectives according to the learning plan. Next, the graph is populated and connected recursively with learning objectives, objects and concepts according to a breadth first strategy using a defined set of connection types. Currently, the exploited connection types are five: "*satisfies*" between a Learning Object and an Objective; "*subject*" between a Learning Object/Objective and a Concept; "*hasBloom-Level*" for Learning Objectives and the Bloom level; finally "*hasParent*" /" *hasChild*" between Concepts. The learning space generation algorithm is set to expand uniformly all possible connection chains with maximum Concept distance 2 from each initial learning objective *(#46* in our case). Using the initial set of the learning plan, the generated learning space graph involves 46 Learning Outcome, 52 Learning Object and 93 C programming Concept nodes. Next, the learning space synchronizes according to the student relevant data from the student log. In our scenario, the course has just started so there is no relevant data in the student log. At this point, the student is able to use the recommender. A graphical representation of the learning space is depicted in Fig. 6. This graph represents a fraction of the learning map that is built to support the goal of learning the semantics of C operators. Learning Objects are not shown for clarification reasons.

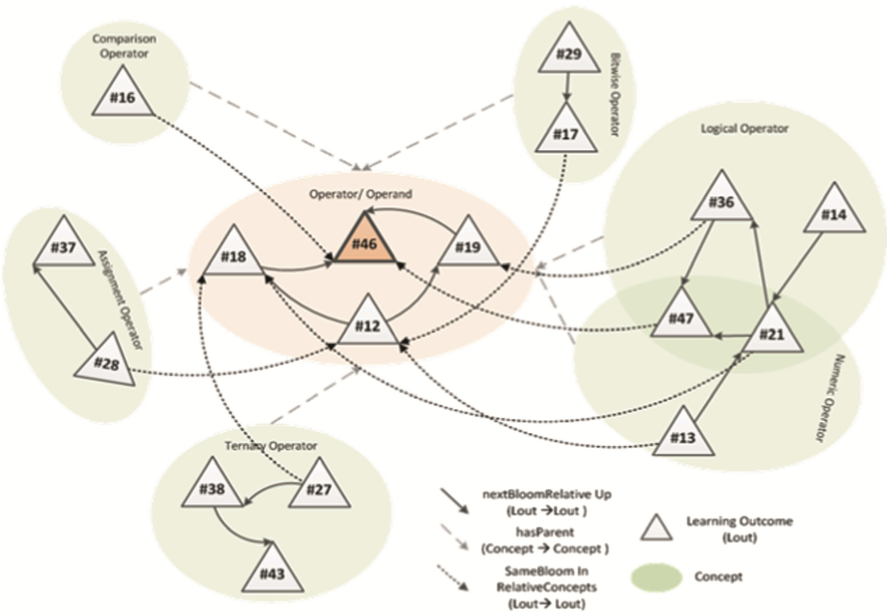

Fig. 6. Simplified representation of the learning space in the context of the example course.

When the student selects the recommendation button, the event is passed to the tutor agent who calculates and returns back a list of the most valued objectives of the learning space, according to the dominant learning tactic. Each learning tactic applies to each Learning Objective (node) of the learning space as follows:

- rapid-advance: each node x estimates its score based on the formula: $f(x) = 1/(1 + dist) * \#nodes_{in,finished} / \#nodes_{in} * \left(\#nodes_{out} - \#nodes_{out,finished}\right) /$

$\#nodes_{out}$ where *dist* is the distance of a node from the closest learning goal, $\#nodes_{in/out}$ is the number of connected incoming/outgoing nodes and $\#nodes_{in/out,finished}$ is the number of finished incoming/outgoing nodes. If there are no incoming nodes, $\#nodes_{in,finished} = nodes_{in} = 1$. If there are no outgoing nodes, $(\#nodes_{out} - \#nodes_{out,finished})/\#nodes_{out} = 1$

- greedy: each node x estimates its score based on the formula: $g(x) = \#nodes_{in,finished} - \#nodes_{in,pending}/\#nodes_{in}$, where $\#nodes_{in,pending}$ is the number of (incoming) nodes that are not finished. If there are no incoming nodes, $g(x) = 1$

To better understand how a learning tactic affects the recommendation, consider Learning Objective nodes 16, 19, 36, 27, 13 and 47: assuming there are no (visited/finished) nodes, the former learning tactic will estimate values ½, 0, 0,1/3, ¼ and 0 respectively. According to this, the rapid-advance tactic will recommend the sequence 16, 27 and 13. The latter tactic will estimate 1, -1, -1, 1, 1 and -1 respectively, leading to a random recommendation sequence for 16, 27 and 13, since all nodes have the same weight. If we assume nodes 16 and 21 as visited, the values for 19 and 27 are not affected (neighbours are unchanged). Nodes 36, 13 and 47 are affected, giving estimations 1/3, 1/8, ¼ for the former and 1, 0, 1 for the latter learning tactic. Thus, the rapid-advance tactic will recommend the sequence 36, 27 and 13, whereas the greedy tactic a random sequence between 36, 27 and 47.

When the student selects an objective to attain, the selection is passed to the agent who calculates and returns back a list of the existing learning objects with respect of the selected objective and the student preferences, located in the student profile (Fig. 7) (the language used in the user interface is currently Greek). For example, if the student prefers visual content and the objective concerns the topic "recursive functions", a video learning object will be selected, if available, explaining this topic. It is noted that the agent sorts instead of excluding learning format/types. Thus, the student is able to select a learning object of his/her choice.

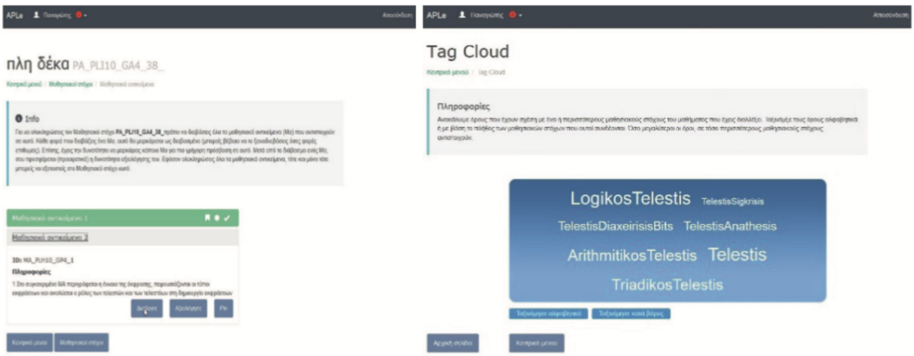

Fig. 7. Screenshots of APLe system user interface: choosing learning objects for a specific learning outcome (on the left); tag cloud service (on the right).

In addition, to the main screen, the student can see a tag cloud on the concepts which appear in the current educational path, as given in Fig. 7. Furthermore, the student can classify concepts according to their weight or alphabetically. Selecting a specific tag concept, the student is driven to all learning objects associated with the specific concept. It should be noted that in this way the user overrides the tutor agent; the later will be able, however, to adapt to the new context (learning object selected by the student).

Finally, when the student finishes the study of a particular learning object, the student has to self-evaluate his/her understanding on the learning object. This action triggers the agent to update the learning space and the student data repository. Also, the agent updates its indicator data for the class.

4 Evaluation

For a preliminary evaluation of the proposed system we conducted a small-scale evaluation, where the participants were members of the Educational Content Methodology & Technology Laboratory at HOU. Fifteen volunteer members of the Lab participated in the evaluation (4 female, 11 female, average age 23.7). All the participants had a computer engineering background and were familiar with the educational content and methodologies of the HOU.

For the evaluation of the proposed agent-based system, our approach involved evaluating the system through user's experiences to find out the usability and impact of the ITS, finding learning rates and achievements level. The first step for the evaluation process was to create a number of new user accounts in the repository with respective credentials (username/password) which were provided to each participant. Along with the credentials an instruction manual of the system was sent to all the participants.

The next step of the preparation of the system in order to be used, was to import an adequate number of learning objects with different file formats and resource types, appropriately created by Hellenic Open University's tutors, corresponding to the learning outcomes of the course "Structured programming in C", as described in Sect. 3.3). By using the property "resource type" of the learning objects, we categorized also a learning object according to its content (e.g. theory, example, exercise, activity etc.). The learning outcomes were updated weekly, according to the curriculum of the course. The evaluation process lasted one month, during which each participant had to use the system and finally complete a questionnaire (which we will describe below).

4.1 Questionnaire

For the completion of the evaluation process, a questionnaire was provided on-line to the participants. The criteria for the evaluation of the APLe, have emerged from the study of different system evaluation methodologies (such as Technology Acceptance Model 2, TAM2) and are represented through scored questions. More specifically we have used the likert scale (5-point scale). There is also a number of open questions about general comments and remarks.

The questions were divided in three categories: (1) Usability, (2) Educational content and (3) Adaptivity. Briefly, in the first category there are questions about the easiness of using the system, the interface, navigation features, functions and menus. The second category includes questions about the relevance of the learning objects with the learning goals, the validity of the educational content, how the knowledge acquisition through APLe is facilitated and what are the main flaws regarding the content and types of the learning objects. Finally, questions in the last category concern the completeness of the forms for the creation of the student profile, if there are any other parameters besides those included in the profile, that affect the adaptivity of the system that we should take into account and finally the creation of the educational paths.

4.2 Results

In this section, we briefly present and discuss the results of the evaluation process as they were captured through the questionnaire that the participants had to complete after the use of the APLe system at the end of the evaluation period of one month.

In the question whether the APLe system is easy to learn, 100 % said that they agreed or strongly agreed. When the participants asked whether the navigation functions are easy to understand, 80 % answered positively, while 20 % disagreed or remained neutral. In the question if the overall user interface is friendly, more than 87 % agreed and strongly agreed and only 12.5 % disagreed. We also received some remarks about some of the functionalities which are mainly front-end issues like the use of natural language in the description of the learning objects that could be easily solved.

Regarding the educational content, in the question whether the content is relevant to the learning goals, 90 % agreed while 10 % remained neutral. In the question whether the educational content is valid, 89 % agreed and 11 % remained neutral. In the question whether knowledge acquisition in facilitated through the use of the APLe system, 72.5 % agreed while 27.5 % remained neutral. Some of the major shortcomings related to the educational content integrated in the APLe system, as remarked by the participants, was the lack of more rich educational content types such as self-assessment activities, self-evaluation tests, etc.

Finally, regarding the adaptivity of the system, in the question whether the forms that the APLe uses for the creation of the learning profile of the student are complete and easy to understand, 87.5 % agreed and strongly agreed, while 12.5 % remained neutral. In the question whether the APLe system is capable to support the student's learning profile (by adding and using more and different learning formats of learning objects), 87.5 % agreed and strongly agreed, while 12.5 % remained neutral. Regarding the creation of the learning paths and if they meet the user's learning preferences, while there was a positive feedback (80 % agreed and strongly agreed) highlighting as a positive remark the capability offered by the system to override the system suggestions through the tag cloud service, there was also a critique that it was not clear to the user how the learning paths are created (e.g. a diagram) and more feedback on that would be helpful.

From the above brief presentation of the results, it becomes clear that, regarding the usability of the system there was a positive assessment for both navigation and learning of the system. In relation to the educational content the majority of the participants were positive towards the content (learning objects), and were encouraging on whether the APLe system is able to enhance the traditional way of learning with the remark that more types of educational content should be added. Regarding the adaptivity of the system, almost all participants found complete and fully understandable the forms for the creation of the student profile, they consider that APLe is adapted to the student learning profile and preferences, while on the creation of the learning paths there were requests to provide more feedback on their creation.

In the next section we present some of the next steps and suggestions in order to improve the functionality and reliability of the system.

4.3 Discussion

The advantage of the agent-based platform derives from the fact that the tutor agents can provide recommendation on a sequence of learning outcomes that most fit the student profile, according to the properties of the learning objects. On the other hand, the use of ontological models for representing and storing the information regarding the learner and the learning material enhances reusability of this information and promotes interoperability with third-party systems.

According to the results of the small-scale evaluation we present in the previous section, the next step is to integrate to the APLe system a number of learning objects with different metadata and for various knowledge domains. These objects have different file formats (video, document, presentation, etc.) and different resource type (activity, exercise, self-assessment, etc.). We also plan to prepare some tests which will form the basis for the fulfillment of a learning goal.

Regarding the creation of the learning paths, we plan to integrate a module to the system which will provide to the student an overall picture of his/her learning progress and the next steps he/she has to follow. This would be in a form of a diagram, for example, which will be accessible at any time by the student.

Finally, and after we have made the necessary updates we plan to evaluate the proposed system during the time-period of a semester with students of HOU. Our final goal is to provide to the community of the HOU the APLe system as an integrated system that will assist students during the educational process.

In HOU, we are developing (in a collaborative effort among ontology experts and course tutors) educational ontologies for the majority of the 600 courses we offer. Our aim is to gradually introduce these ontologies to the platform and deploy the respective agents for each course. Currently, about 40 courses are in the “pipe-line”. The platform will eventually become a component of the HOU educational portal, which will offer a personalized learning environment to our students. In its first deployment, the course ontologies will be independent, thus a different instantiation of the platform per course is planned. This approach will also help us sidestep scalability issues and allow us measure system’s performance, so as to plan the next deployment phase.

5 Related Work

Multi agent system (MAS) is a technology where its application came into existence during 1980's. A number of e-learning systems use the multi agent scheme to create sophisticated environments in order to achieve maximum effectiveness in learning by implementing different technologies and using different methodologies [21]. An example in the domain of multi-agent e-learning systems is [22] where the authors present a multi agent approach for designing an e-learning system architecture. The proposed architecture consists of four tier layers, namely Interface layer, Middle layer, Database Controller layer and Database layer. The middle layer is based on MAS and supports any information communication, login, logout and new user sessions creation. Another example of a multi agent system that exploits ontologies for describing the educational material as well as the learners and their learning styles is presented in [23]. The authors here present an architecture to support a multi-agent e-learning system, where intelligent agents are capable of providing personalized assistance according to learner's learning style and knowledge level. In [24] a study describes an architecture composed of four multi-agent system levels interacting with each other using intelligent blackboard agents; blackboard agents facilitate the cooperation and coordination among interacting agents. Each level consists of different agents specialized on interfacing, authoring and learning aspects depending on the human user role. The system is connected to a number of databases modelling the student profile, the learning process, the learning domain, teaching material and practices.

The authors in [25] apply a Memetic Computing methodology into a hierarchical multicore multi-agent system while formalizing memetic agents' exploration of taxonomic knowledge as an optimization problem in order to compute personalized learning experiences. Their approach includes building a set of knowledge highways whose paths connect information sources, earner's requirements and cross feasible learning contents. Memetic agents explore the available learning knowledge taking into account hardware details of the available computing resources. The domain model employs a semantic representation of the educational domain including a set of teaching preferences; the learning presentation generation algorithm uses a predefined learning path of concepts to be covered and generating the best sequence of learning activities to best satisfy the concept path. In [26] the authors suggest a framework for building an adaptive Learning Management System (LMS). The proposed architecture is based upon multi-agent systems and uses both Sharable Content Object Reference Model (SCORM) 2004 and Semantic Web ontology for learning content storage, sequencing and adaptation. Moreover, they provide a way to adapt course topics according to learners' experiences whose learning style is similar to the current learner.

6 Conclusions

In this work an approach for building an intelligent tutoring system was presented, based on a multi-agent architecture and combined with ontologies for knowledge representation. The system developed is focused on a bottom up, reactive generation of an active sequence of knowledge units regarding a set of adjustable, high level learning goals. The learning process begins with a set of simple learning goals that require a few learning objects and as the educational process proceeds, the student has to achieve higher learning outcomes that combine other low level outcomes which have been already achieved. The system is able to adapt to student's learning profile and progress by applying proper learning tactics to prioritize through a weight calculation scheme the sequence of the learning outcomes to achieve. The main components of the system consisting of ontological models of the learner and the subject under study, gateway agents and tutor agents with their core modules (learning space management and learning tactics control) were explained and a detailed description of their interaction was given in the context of an example application. Finally, the advantages of the proposed approach were laid out, especially in the setting of a distance learning education system.

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References

1. Polson, M., Richardson, J.: Foundations of Intelligent Tutoring Systems. Lawrence Erlbaum Associates, Mahwah, New Jersey (1988)
2. Nkambou, R., Mizoguchi, R., Bourdeau, J.: Advances in Intelligent Tutoring Systems. Springer, Heidelberg (2010)
3. Sossa, H., Peña Ayala, A.: Semantic representation and management of student models: an approach to adapt lecture sequencing to enhance learning. In: Sidorov, G., Hernández Aguirre, A., Reyes García, C.A. (eds.) MICAI 2010, Part I. LNCS, vol. 6437, pp. 175–186. Springer, Heidelberg (2010)
4. Bellifemine, F., Caire, G., Pogg, A., Rimassa, G.: Jade a white paper. Telecom Italia EXP Mag. **3**(3), 6–19 (2003)
5. Noy, N., McGuiness, D.: Ontology development 101: a guide to creating your first ontology. Stanford Knowledge Systems Laboratory Technical report KSL-01-05 and Stanford Medical Informatics Technical report SMi-2001-0880 (2001)
6. McGuinness, D.L, van Harmelen, F.: OWL web ontology language overview W3C recommendation (2004). http://www.w3.org/TR/owl-features/
7. Smythe, C., Tansey, F., Robson, R.: IMS Learner Information Package Information Model Specification, IMS Global Learning Consortium. http://www.imsglobal.org/profiles/lipinfo01.html
8. LTSC Learner Model Working Group of the IEEE 2000. Draft Standard for Learning Technology - Public and Private Information (PAPI) for Learners (PAPI Learner), p. 1484.2/d7. IEEE, 28-11-2000
9. Fleming, N.D., Mills, C.: Helping students understand how they learn. The Teaching Professor, vol. 7(4), Magma Publications, Madison, Wisconsin, USA (1992)
10. Nikolopoulos, G., Solomou, G., Pierrakeas, C., Kameas, A.: Modeling the characteristics of a learning object for use within e-Learning applications. In: 5th Balkan Conference in Informatics, pp. 112–117. ACM, New York (2012)

11. Kameas, A., Pierrakeas, C., Kalou, A., Nikolopoulos, G.: Creating a LO metadata profile for distance learning: an ontological approach. In: Dodero, J.M., Palomo-Duarte, M., Karampiperis, P. (eds.) MTSR 2012. CCIS, vol. 343, pp. 37–48. Springer, Heidelberg (2012)
12. Bologna Working Group, A Framework for Qualifications of the European Higher Education Area. http://ecahe.eu/w/images/7/76/A_Framework_for_Qualifications_for_the_European_Higher_Education_Area.pdf
13. Anderson, L.W., Krathwohl, D.R., Bloom, B.S.: A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman, London (2001)
14. Kalou, A., Solomou, G., Pierrakeas, C., Kameas, A.: An ontology model for building, classifying and using learning outcomes. In: 12th IEEE International Conference on Advanced Learning Technologies, pp. 61–65. IEEE, New York (2012)
15. Panagiotopoulos, I., Pierrakeas, C., Kameas, A., Kalou, A.: An ontological approach for domain knowledge modeling and management in e-learning Systems. In: Iliadis, L., Maglogiannis, I., Papadopoulos, H., Karatzas, K., Sioutas, S. (eds.) Artificial Intelligence Applications and Innovations, Part II. IFIP AICT, vol. 382, pp. 95–104. Springer, Heidelberg (2012)
16. Nikolopoulos, G., Solomou, G., Pierrakeas, C., Kameas, A.: An instructional design methodology for building distance learning courses. In: 7th International Conference in Open and Distance (2013)
17. Foundation for Intelligent Physical Agents (FIPA). FIPA ACL Message Structure Specification (2002). http://www.fipa.org/specs/fipa00061/
18. Bishop, B., Kiryakov, A., Ognyanoff, D., Peikov, I., Tashev, Z., Velkov, R.: OWLIM: a family of scalable semantic repositories. Semant. Web **2**(1), 33–42 (2011)
19. Popham, W.J.: Transformative assessment in action: an inside look at applying the process. ASCD, Alexandria, USA (2011)
20. Brooks, R.A.: Intelligence without representation. Artif. Intell. **47**, 139–159 (1991)
21. Bokhari, M., Ahmad, S.: Multi-agent based e-learning systems: a comparative study. In: 2014 International Conference on Information and Communication Technology for Competitive Strategies. ACM, New York (2014)
22. Ali, A.P., Dehghan, H., Gholampour, J.: An agent based multilayered architecture for E-learning system. In: 2nd International Conference on E-Learning and E-Teaching (ICELET), pp. 22–26. IEEE, New York (2010)
23. Dung, Q.P., Florea, M.A.: An Architecture and a domain ontology for personalized multi-agent e-Learning systems. In: 3rd International Conference on Knowledge and Systems Engineering, pp. 181–185. IEEE, New York (2011)
24. Hammami, S., Mathkour, H., Al-Mosallam, E.A.: A multi-agent architecture for adaptive E-learning systems using a blackboard agent. In: 2nd IEEE International Conference on Computer Science and Information Technology, pp. 184–188. IEEE, New York (2009)
25. Acampora, G., Loia, V., Gaeta, M.: Exploring e-Learning knowledge through ontological memetic agents. IEEE Comput. Intell. Mag. **5**(2), 66–77 (2010)
26. Yaghmaie, M., Bahreininejad, A.: A context-aware adaptive learning system using agents. Expert Syst. Appl. **38**(4), 3280–3286 (2011)

Recognition of Reading Activities and Reading Profile of User on Japanese Text Presentation System

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Abstract. In Japanese public elementary schools, every pupil may use an ICT device individually and simultaneously. In the cases, a few teachers must teach all pupils. For being welcomed from a teacher, the ICT devices must help pupils to use the ICT devices by itself for effective usage, and it must help the teacher to use the ICT devices in a class. For help the users, the ICT devices must understand the state of the user. For help the teacher, it must estimate the users' profile from the recorded users' activities. This paper proposes a method to recognize the reading activity of a user with read aloud voices and the profile of a user with operational records. The proposed method is implemented. Experiments confirm the performances for measuring the reading activity of a user and for recognizing a user's profile of reading activities.

Keywords: Reading difficulty · Text presentation · Assessment · Activity analysis

1 Introduction

Information and communication technology (ICT) spreads in Japanese public elementary schools. In Japanese public elementary schools, every pupil may use an ICT device individually and simultaneously. In the cases, a few teachers in most cases one teacher must teach all pupils. A class have 40 pupils at most in Japanese public elementary schools. The median of the numbers of pupils is about 32 in Utsunomiya Japan.

The usage of the ICT devices makes many benefits and problems. Each individual device makes many measurements about reading activities. This is a large benefit of usage of individual ICT devices. However, a large amount of measured data themselves make problems for a teacher. The measured data must be processed for effective usage in classes. The largeness of the measured data makes difficult to process. There are many easy problems to use an ICT device. However, one teacher cannot handle all of the problems and benefits about the usage of ICT devices individually and simultaneously.

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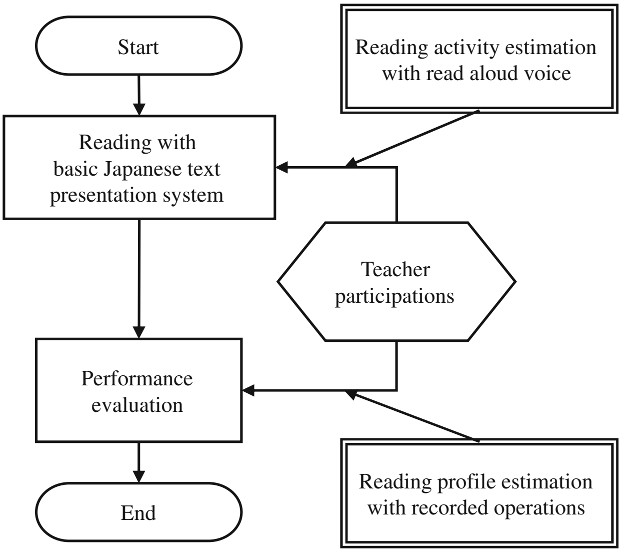

Fig. 1. Teacher's participations and our new supports for decreasing them.

We will cover the easy problems with the ICT device itself. In Japan, a normal class includes about 32 pupils. About 20 % of pupils have some problems about using ICT devices. We will cover the 80 % of the problems with ICT device itself. In the case, the teachers can treat only two pupils that have the problems not covered by the ICT device itself. We will cover the works with the ICT device itself. We will process the measured data about reading activities by the ICT device. A teacher can concentrate upon his work for utilize the processed results.

For treating the problems caused with the usage of ICT devices and helping a pupil and a teacher, the ICT systems must recognize the user's activities. The Japanese text presentation system was proposed for helping the pupils with or without a reading difficulty [1]. In the Japanese text presentation system, the activities of a user are key touches, eye movements, and read aloud voices. Figure 1 shows the relations between teacher participations and our new supports for decreasing the participations. ICT devices may generate large new data. For instance, Japanese text presentation system measures and records the precise operations. These new data are useful for understanding pupil's reading profile. However, these new data create new work load for a teacher.

The pupil may leave the ICT system. Our system does not have arms. It cannot prevent to leave the pupils from the front of the ICT system. However, teachers can treat this kind of problems. Many pupils use the ICT system well. However, many simple problems prevent to use the system well. A new work-load may prevent a teacher to use ICT devices. Our goal is to decrease the work of teachers to introduce ICT devices in a class. A teacher needs to participate at a time using ICT devices and at a time after using ICT devices. Shown in Fig. 1, we will decrease both participation with reading activity estimation and reading profile estimation. ICT devices introduced in a class must be useful for pupils. And, the ICT devices introduced must be welcomed by teachers.

In Japan, if a pupil shows two years delay of reading ability, we say that the pupil has a reading difficulty. Some Japanese normal public elementary schools have about 20 % of pupils with a light reading difficulty. Of course, there are pupils with a heavy reading difficulty. The pupils with a heavy reading difficulty attend special support education classes or schools.

A reading ability is most important for learning in a school. Almost all materials are text books. Recently, multimedia materials have increased gradually. However, in multimedia materials, texts have an important role. The pupils with a reading difficulty have a large handicap in all subjects. Even if a pupil has enough intelligence, with a reading difficulty the pupil has difficulty about learning all subjects. The helping method for the pupils with a reading difficulty is important.

This paper proposes the method to recognize and to analyze the activities of the user on the Japanese text presentation system that helps to read Japanese texts with or without reading difficulties, and the system decreases the work of teachers who help the pupils.

There are many pupils with a reading difficulty in Japanese elementary schools. There are many difficulties. The big and first one is reading Japanese characters. Japanese characters are the construction of hiragana (phonetic character), katakana (another type of a phonetic character), kanji (Semantic character) and other characters. In the period of elementary school, pupils learn 48 characters of hiragana, 48 characters of katakana and 1008 characters of kanji. Almost all pupils learn hiragana and katakana easily. However, the huge number of kanji is difficult to learn for some pupils in normal classes [2].

The next one is the difficulties about recognizing the sentence structures. In Japanese sentences, there is no spacing between words. For easing the difficulties about reading kanji characters, we can replace kanji characters with the hiragana characters. We can write hiragana characters that represent the pronunciation of the kanji characters at the side of the kanji characters.

We recognize the words constructing the Japanese text in the help of kanji. There are a large number of words starting from the character of kanji. We recognize the chunk of characters that constructs a word for the complex of hiragana, katakana and kanji.

Replacing kanji characters with hiragana characters, we have the sequence of hiragana characters only. In a long sequence of hiragana, it is difficult to recognize the chunk of characters constructing a word. It has no problems of this kind to write hiragana characters at the side of kanji characters.

In an elementary school, pupils learn hiragana and katakana at first. In the first stage in elementary schools, the Japanese text-books have a space between words for the ease of understanding the structures of the sentences. However, normal Japanese texts have no space between words.

Every pupil has those two difficulties at first. In a long school life, they acquire the skill to conquer those difficulties. Anyway, those two difficulties are large barriers for reading and understanding Japanese sentences.

Every infant has no knowledge about the Japanese characters. Every pupil has a little knowledge about the huge number of kanji characters at first. Then, they learn hiragana, katakana and kanji characters in a long elementary-school life.

In Japanese elementary schools, reading difficulty means two years delay of reading abilities. A few of pupils with dyslexia learn in special support education classes or schools. However, there are many pupils with reading difficulties in normal elementary schools. Of course, some pupils have difficulty about remembering kanji characters. Most of the pupils remember kanji characters gradually. However, pupils with a learning disability tendency have difficulty with reading Japanese sentences in the case that they can remember the kanji characters. In the case, they may be dyslexia.

There may be many causes of the difficulties on reading Japanese texts. We do not discuss the causes. We only pay attentions to the methods for easing their difficulties. We call their difficulties as "reading difficulty" in this paper.

The research about teachers shows that the pupils with ADHD (attention deficit hyperactivity disorder) tendency have difficulty about following the characters sequentially and recognizing the grammatical structures [4]. Of course, there are many types of reading difficulties. There are many causes of the reading difficulties. The resulting reading difficulties show the similar symptoms. They are the difficulties about following the characters sequentially, recognizing grammatical structures and reading kanji characters.

We have developed a visual text presentation system for persons with a reading difficulty in windows environments. The system records every operation of a user. With the recorded operations, we assess the difficulty of the user.

The Japanese text presentation system was proposed and implemented for the pupils with reading difficulties [2]. The system provides the multi-level high-lighting. The system makes the precise record of the operations. With the operational record, we can assess the reading abilities and difficulties on objective base, and reading profile.

For treating the problems caused with the usage of ICT devices and helping a pupil and a teacher, the ICT systems must recognize the user's activities. In the Japanese text presentation system, the activities of a user are key touches, eye movements, and read aloud voices.

The pupil may leave the ICT system. Our system does not have arms. It cannot prevent to leave the pupils from the front of the ICT system. However, teachers can treat this kind of problems. Many pupils use the ICT system well. However, many simple problems prevent to use the system well.

This paper proposes the method to recognize the activities of the user with the read aloud voices for decreasing the work of teachers who help the pupils with or without reading difficulties.

First, this paper proposes the Japanese text presentation system with user's activity recognition based on the read aloud voices. Then, we discuss precisely the plan of the Japanese text presentation system recognizing reading activities with read aloud voices in a normal Japanese class room. Next, we discuss the method to analyze the reading profile of a user from the reading patterns. Then, we propose the implementation of the system. Next, we show the experimental results. And last, we conclude this work.

2 Japanese Text Presentation System with Recognition of Read Aloud Voices

The Japanese text presentation system records all the operations of a user. The Japanese text presentation system moves the high-lighted part in a text with the key-input of the user. However, with only the key operations, we cannot recognize precisely the reading activities of a user. For instance, a user may only type a proper key with a proper interval without no reading activities. For recognizing a reading activity and helping the user, the system needs to observe the reading activity with a more direct method. In the usage of the system, the user read aloud Japanese sentences. One direct observation method of the reading activity is the measurement of a read aloud voice. The read aloud voice is a direct result of reading activity. The eye movement is important for understanding a reading activity. However, with eye movements, we cannot have any information about reading results. So, we start from the analysis of read aloud voices. The read aloud voice is the result of reading activity itself. We can evaluate the performance of reading activity directly.

In the usage of the Japanese text presentation system, the user directs the move to the next high-lighted part with a key-input. The Japanese text presentation system records the key operations with the precise time. With the record, we can measure the time for reading the high-lighted part.

With the proper operations, the resulting information is important for understanding the reading profile of a user. For confirming the proper operation of the Japanese text presentation system, we use the voice of reading aloud.

2.1 User's Activity About Reading

Using Japanese text presentation system, the usage is simple as shown in Fig. 2. A user read a high-lighted part of a text, then types a key to move the high-lighted part. In the simple process, a user looks at the display, follows the text, recognizes the characters, understands the high-lighted chunk of characters, read aloud and types a key. Figure 3 shows more precise flow of reading aloud. The Japanese text presentation system cannot help a user to look a display. However, the Japanese text presentation system helps to find a proper sentence on the display with high-lighting the sentence and masking other sentences weakly. The system helps the user to find a chunk of characters with high-lighting also. We cannot observe the process of understanding. However, we can observe the read aloud actions and eye movements. We can observe the expressions on a user's face and body movement also. For guiding and helping the user of the Japanese text presentation system, the eye movement and the read aloud voice are important.

The read aloud activity is a direct result of a reading. We target the read aloud activity at first. With the recognition of read aloud activities, we can assess the reading ability directly.

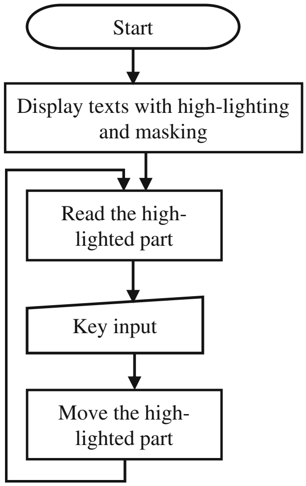

Fig. 2. Operations on Japanese text presentation system.

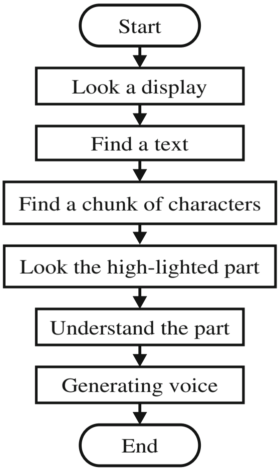

Fig. 3. Precise activities to read a text aloud.

2.2 Reading Activity Measurement Based on the Reading Aloud Voices

For assessing, we use the relation between the reading time and the length of the high-lighted part. For measuring the length of a high-lighted part of texts, there are many measures. One is the number of characters, and the other is the number of phonemes. In our pre-experiments, it shows clear relations between the reading time and the number of characters of the high-lighted part of a text. We use the number of characters for measuring the length of a text. In Japanese texts, there are kanji characters, hiragana characters and etc. As a result, there is a change of phonemes at a character. However, the number of character shows better relation to the reading time.

The Japanese text materials differ in the target age of the readers. For elder pupils, the materials include more kanji characters. A single kanji character represents a same word that is represented using many hiragana characters. The elder pupils read faster than the younger pupils do. As a result, there are constant relations between the number of characters and the reading time of a material.

Without reading difficulties, there is a linear relation between the reading time and the length of the high-lighted part. However, in real reading, there are many miss-operations and reading difficulties. Figure 4 shows the example of the relation between the reading time and the length of the high-lighted part. There are points on a linear function and outlier points.

We decide the outlier points in the reading time per character of the high-lighted part. We use a simple threshold for this process. We decide that the reading time per character without reading difficulties are between 0.1 S and 0.3 S. We plot the pairs of the length and the reading time of the high-lighted parts after filtering the outliers with the threshold in Fig. 5.

The outlier points may represent a reading difficulty or some error operations. It is important for understanding the reading activity to distinguish a reading difficulty and error operations. Only from the key operations, we have no information for distinguish them.

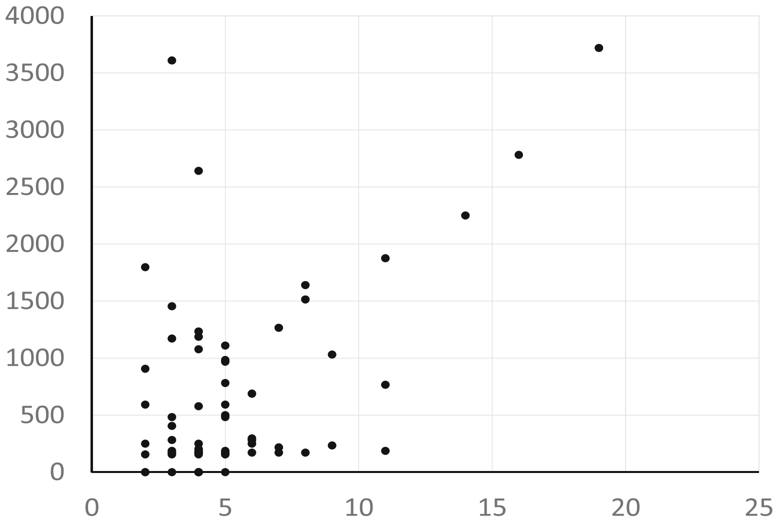

Fig. 4. Relation between reading time and the length.

With read aloud voices, we can easily recognize the reading activities. However, it is difficult to recognize the relation between the read aloud voice and the high-lighted part of a text. The observed voice may be only a talking to oneself. The observed voice may be a correct read aloud of the high-lighted part of a text. The read aloud voice

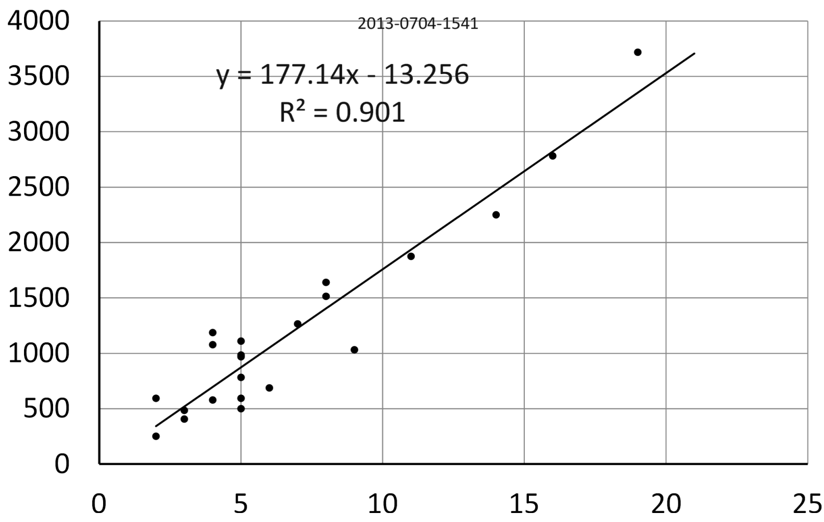

Fig. 5. Relation between reading time and the length without out-lire data.

includes some error pronunciations of the high-lighted part of a text. However, pupil is not an announcer. Their pronunciations are not clear.

Normal speech recognition is powerful now. With the power of a web cloud, our smart phones recognize our speech well. However, dictations of long sentences are difficult. With a long sentence, a speech recognition makes some errors.

In Japanese elementary schools, the Internet connection is more or less restricted for keeping security. In the environment, powerful cloud-based speech recognition cannot work. We must use the poor speech recognition system that works without the Internet connection. In the environment, the Japanese text presentation system must recognize the reading activity of a user with error some results of speech recognitions.

In Fig. 5, the pairs of the length and the reading time have the relation of linear function clearly. With the reading difficulties, the pupil needs much more reading time. As a result, the high-lighted parts where the user has difficulties for reading are plotted upper regions over the linear function.

The plotted points over the normal linear function direct the reading difficulties. The corresponding part of the text shows the kinds of reading difficulties.

3 Analysis of Reading Profile from Reading Activities

If we control the reading activities of a pupil well, we have a record of reading activities of a pupil. With the record we can analyze the reading profile of the pupil. Our former works show the linear relation between the reading time and the length of a high-lighted part without reading difficulties. However, with reading difficulties it is difficult to find the linear relation between the reading tine and the length of a high-lighted part clearly. However, almost all pupils have a little problems about reading a sentence. The clarity of the linear relation is lost in the case.

3.1 Reading Profile Based on the Linear Relation Between the Reading Time and the Length of a High-Lighted Part

The Japanese text presentation system records the key operations by a user. The key operation is apparent presentation to read the next part in a text. The records the key operation, the high-lighted part of a text, and the time of the key operation. From the records, we have the length of the high-lighted part and the time to read the high-lighted part. If there is no reading difficulties, we have clear linear relation between the length of the high-lighted part and the time to read the part. However there is a little reading difficulties. In the case, the linear relation may not be clear.

3.2 Finding Linear Relation from Recorded Key Operations

Our former works show that the 1.5 s delay from normal reading time shows a reading difficulty. However, there is no normal reading time before hand. There are some patterns in reading profiles. Someone takes much time before starting to read aloud. Someone takes less time before starting to read aloud and read more slowly.

For finding the linear relation that represents the profile of reading activities, we must find the relation from the records that include the reading difficulties. So, we need to exclude the data that represent the reading difficulties. We assume that in a normal class there is no pupil who have heavy reading difficulties. The pupils with heavy reading difficulties attend special support education classes or schools. In this assumption, the records in a normal class include many of normal reading activities. In the case, we can distinguish a reading difficulty in the record.

In the record, we have enough number of normal reading activities. From the record, we calculate the linear approximation of the distribution of recorded data. The linear approximation represents the mixture of normal reading activities and reading difficulties. However, there are enough normal reading activities. We decide that the data that need 1.5 s more reading time represent reading difficulties. We exclude the data from the total recorded data. And we repeat this process until there is no data excluded. The remaining data must include only normal reading activities. From the remaining data, we can estimate the reading profile of a user. The resulting reading profile represents the feature of reading activities without reading difficulties. The profile helps a teacher to understand the type of a pupil in reading activities.

3.3 Profiles of Reading Activities

At each pupil, we have the reading profile represented by the linear relation. A linear relation is represented using two parameters. One represents the slant of the line of the liner relation. And, the other represents the vertical position of the line. The slant represents the speed of reading. The vertical position represents the leading time before starting to read aloud. In a reading session, we have these two parameters and the number of reading difficulties that are excluded from the original record. As a result, at a session, we have three parameters. In 2-dimensional space, it is difficult to represent the three parameters. However, we need to represent the three parameters in a sheet.

So, we use bubble graph to represent the three parameters. We represent two parameters describing the linear relation that shows the reading profile with the position of a bubble. We do one parameter describing the number of reading difficulties with the size of a bubble.

The bubble chart represents the reading profile and the reading difficulty in a sheet. That helps a teacher to understand the reading ability and reading type of a pupil. With plotting a number of pupils in a sheet, we have the landscape of reading activities and difficulties in a class.

4 Implementation of Japanese Text Presentation System with Recognition of User Activity

4.1 ICT Environments

A normal personal computer has a microphone to be able to catch the voices of user's read aloud. The basic function of the Japanese text presentation system is to present the Japanese text properly for easing the reading difficulties of a user without any stress. The system must move the high-lighted part without no delay after a key-input.

Speech recognition needs some processing time. A key operation and a reading aloud are asynchronous activities. So, the system processes the task around the key operations and one around voice recognition simultaneously.

In Japanese elementary schools, the Internet connection is more or less restricted for keeping security. In the environment, powerful cloud-based speech recognition cannot work. We must use the poor speech recognition system that works without the Internet connection. In the environment, the Japanese text presentation system must recognize the reading activity of a user with error some results of speech recognition.

The assessment process needs large amount of teacher contributions. In reading with the Japanese text presentation system, teachers monitor the process of the readings. After that, teachers see the operational records. This assessment results an objective estimation of the reading difficulties of the user. However, there is a little difference of the teacher contributions between the assessment using the Japanese text presentation system and the classical assessment methods.

In the reading processes, a pupil may read the part that is not high-lighted. A pupil may make un-correct pronunciation. Those events make no marks in the operational record. The observing teachers guide the pupil for proper operations of the Japanese text presentation system. The teachers also record the un-correct pronunciations.

The Japanese text presentation system tries to help every pupil with reading difficulties in a normal class room. In Japanese elementary schools, there are a few pupils with reading difficulties. The teacher must make a class for the majority of normal pupils. The teachers need the day by day assessments of reading difficulties for evaluating their teaching to ease the reading difficulties of a pupil. With the present Japanese text presentation system, teachers can assess the difficulties about reading. However, the Japanese text presentation system needs many works with teachers. For enabling day by day assessments of reading difficulty, we must decrease the teachers' contributions for assessing the reading difficulties.

4.2 Class Room

There are many problems for utilizing the ICT technology in Japanese elementary schools [4]. The problems are listed in Table 1. For solving the problems, the proposed text presentation system treats only the electronic text. In Japan, a law forces to prepare the electronic readable texts of text books [3]. And, there are many documents accessible through the Internet. There is no paper document for an input in the proposed system.

Many pupils may remember the full text of the many times used materials as text books. Those remembered materials cannot be used for evaluating the reading performance of a pupil. The reading of the materials cannot help to enforce the reading abilities of the pupil.

In normal class rooms, many pupils use the Japanese text presentation system simultaneously. In Japan, a class of a public elementary school has about 30 pupils and a teacher. With the instructions of the teacher, we estimate that about 80 % of the pupils work with the Japanese text presentation system properly. There are 20 % of pupils who need a help to use the Japanese text presentation system properly. It is difficult to support 6 pupils by a teacher simultaneously. Our new system will support 80 % of pupils that have some problems to use the system by itself. Then, 2 % of the pupils in a class there are one or two pupils who need helps. A teacher can support the pupils. In the case, all of the pupils in a class work properly with the Japanese text presentation system. There is no need of the complete support for all the pupils in a class. The 80 % support for pupils is enough in a normal class.

Table 1. Problems about ICT usability in a special aid school in Japan.

Special aid school and/or normal school.	Problems
Special and normal	There is a load concentration into the teacher, who is good at ICT
Special	There are a few educational materials for the DAISY [5]
Special	They do not use the SAVE AS DAISY
Special	Using OCR for preparing educational materials for pupils with a learning disability tendency, the recognition errors make a large check and correct work
Special and normal	There are large works for replacing difficult kanji characters with hiragana
Special and normal	Using classical ICT tools as the DAISY, we need to prepare educational materials for each pupil who has a different age and a different disability
Special and normal	It is difficult to evaluate the performance
Special and normal	A teacher is busy in many works

In a normal school, teacher are busy for their day by day works. And they need much time to lead and teach pupils. Not only, a new ICT device must be welcomed from pupils. But also, it must be welcomed from a teacher. To be welcomed from teachers, a new ICT device must not increase the work of teachers.

4.3 System Design

The proposed system has the features listed in Table 2. The proposed Japanese text presentation system has only 2 new functions. We restrict the functions of the proposed system. The new proposed system has the function writing hiragana characters at the side of kanji characters, and the function of analysis of user's voices. With those new functions, the new Japanese text presentation system makes easy to estimate the user's reading difficulties. This is discussed in previous section. The teachers around the pupil with reading difficulties need the objective measurements of the performance of the reading ability of the pupil. For the pupils without reading difficulties, the objective measurements of performance show the progress of the user. For this purpose, the proposed system provides the operation logging function. The operation logs describe the reading speed at each meaningful chunk of characters.

Table 2. The plan for covering the problems.

New/Old	Feature
New	Automatic reading profile estimation
New	Automatic reading activity estimation
New	Writing hiragana characters at the side of kanji characters
Old	Automatic operation observations
Old	Automatic assessment of reading difficulties
Old	A collection of simple software is better than complex multi-functional software
Old	Avoid the usage of OCR (optical Character Reader)
Old	An educational material presentation system that does not need the special material preparations
Old	An evaluation method/function for evaluating the performance of a pupil

The proposed Japanese text presentation system enables to use one-time materials for measuring the performance of a pupil. The real-time presentation generation enables to use any new plain text materials at any time with personalized presentation.

This real-time presentation generation enables to adapt the presentation for each pupil with different reading difficulties. DAISY has no function about adaptation for each pupil.

For adapting the variety of pupils' ages and disability grade, the presentation system has the function to replace the un-studied kanji characters with hiragana characters. The phonic hiragana character is first studied character. There is a little difficulty about reading hiragana.

For easing the difficulty about kanji characters, the new system has another function that adds hiragana characters that represent the pronunciations of the kanji characters at the side of the kanji characters. This presentation helps users to recognize the relation between the kanji characters and their pronunciation.

The operations to the presentation system have the information about the user. The proposed system logs every operation at the time. This log represents the fluency of the reader.

The new system has the function that analyses the voice of read aloud of the user. With the voice of the reading aloud, the new proposed system estimates the pronunciation. With the estimated pronunciations, the new system estimates the reading activity of the user. With the reading activities estimated, the new system can change the presentation. The new system guides the user for proper usage of the system. With the recorded voice, the teacher may check the pronunciations afterward.

The new system has the features listed in Table 2. The first, the second and the third rows are new added features. They decrease the work by a teacher about using the Japanese text presentation system. For wide use of the Japanese text presentation system, the system does not need large-scale contributions of teachers. The network problem is important in Japanese schools. There is a large limitation about the Internet access. As a result, some cloud based implementation cannot work. The proposed system must work without the Internet access.

4.4 System Implementation

Language and Library. We implement the new Japanese text presentation system with Python. The new system uses Julius and Mecab. Julius is a Japanese speech recognition system [6]. Mecab is a morphological analyzer for Japanese sentences [7]. There are Python's interfaces for Julius and Mecab. Our Python based system integrates Julius and Mecab. For Japanese text presentation, the system uses Pyglet [8]. Pyglet provides an object-oriented programming interface for developing games and other visually-rich applications. With Pyglet functions, the new system enables to display any collections of display formats.

Multiprocessing. The new Japanese text presentation system has two major processes. One process takes a work for presenting Japanese text. The other process takes a work for estimating user's activities. With separating a text presentation and an activity estimation, the text presentation works freely from the time-consuming speech recognition. This implementation ensures the light display of texts. Figure 6 shows the

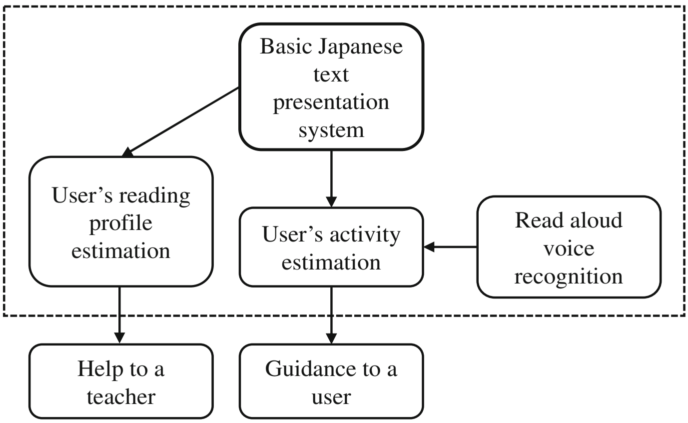

Fig. 6. Japanese text presentation system with recognition of user's activity user's profile.

basic structure of the new Japanese text presentation system. The dashed line box is the range of current implementation. The guidance generation is left for future. Figure 7 shows the outline of the new Japanese text presentation system.

Phoneme Recognition. The Japanese speech recognition system Julius can recognize a speech well with proper preparations. However, in simultaneous use without proper preparations, the Julius cannot show its good performance. In the case, there are many error recognitions. With the error some recognition results, the new system makes the estimation of user's activity with error some speech recognition results. The new system equates similar sounds with each other. The new system recognizes the part where the user read aloud in a text. The correctness of reading is not evaluated. With the recognition of the part of reading aloud, the system recognizes that the user uses the system properly or not.

The Japanese speech recognizer Julius recognizes the chunk of voices. There are many errors in the recognized results. The new system only uses the phonemes.

The new system evaluates the length of phonemes recognized. The number of phonemes is robust in noisy environments. Using the number of phonemes recognized, the new system estimates the correspondence between the phonemes of a high-lighted part of texts and the phonemes recognized from voices based on the length of the phonemes. The new system evaluates the difference between the phonemes of the high-lighted part of texts and the recognized phonemes using Levenshtein distance [9]. With the Levenshtein distance, the new system estimates the correctness of the reading aloud voices for the high-lighted part in the text. In the implementation, the insertion and the deletion take 2 for their edit distances. The substitution's cost is 4 for normal substitutions. Between the nearly same phonemes, the substitution's cost is 2. For instance, 'shi' and 'hi' are nearly same in Japanese. With a threshold, the new system

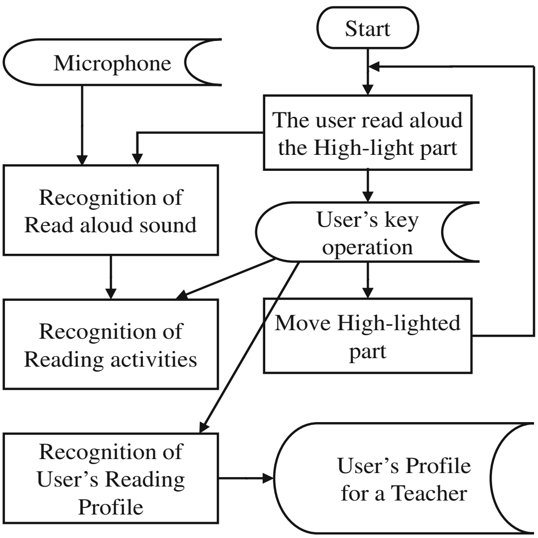

Fig. 7. Outline of the new Japanese text presentation system.

decides the read aloud voice is proper pronunciation of the high-lighted part of a text, or not. Figure 8 shows the precise flow of phoneme analysis.

User's Reading Profile Recognition. To make a user's profile from the recorded data, we must remove the outlier. However, in the original recorded data, it is difficult to distinguish the normal recorded reading activity and the outlier recorded activity. Discussed in 3, our target pupils are normal pupils. The normal pupil has some reading difficulties. However, they can read large part of a text without a large problem. So, we start from the recorded data that include a large number of normal reading activities and a relatively small number of reading difficulties. We estimate the linear approximation of the recorded data. Based on the linear approximation, we decide the outlier data. Then, we remove the outlier data. The resulting data have less reading difficulties. And, again, we estimate the linear approximation and remove the outliers. We repeated this process until there is no outliers. This process is shown in Fig. 8.

5 Experiments

We will help the user by the Japanese text presentation itself. For this purpose, we implement the reading activity estimation with the voice of user's read aloud. The new system records the voice. The new Japanese text presentation system includes the original Japanese text presentation system. The new system includes the function to estimate the reading activity with user's reading aloud voice and the function to make users' profiles for the assessment of a reading difficulty of the users.

5.1 Text Presentation Varieties

The new Japanese text presentation system enables much more varieties of text presentation. The new function displays hiragana characters at the side of kanji characters.

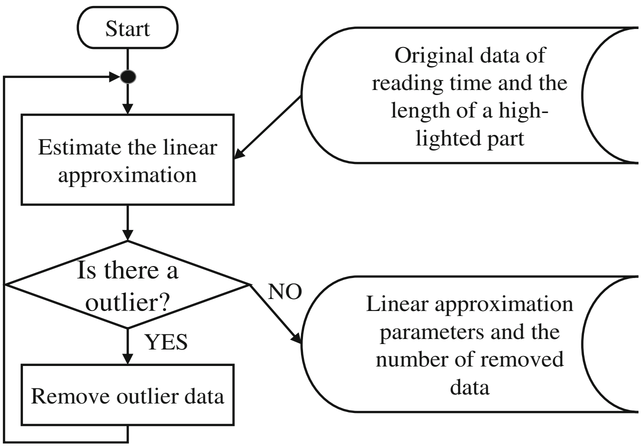

Fig. 8. Process to estimate user's reading profile.

In Japan, it is popular helping method for easing the difficulty of reading kanji characters to write hiragana characters at the side of kanji characters.

The placement of hiragana characters at the side of kanji characters has many methods. Our implementation places the hiragana characters at the center of the word of kanji characters. Figure 9 shows an example of presentation of Japanese texts with hiragana characters writing at the side of kanji characters. The current sentence is high-lighted, and the current part of the sentence is high-lighted with other formats. Other parts of the text is not high-lighted. There are three levels of presentations in the Fig. 9.

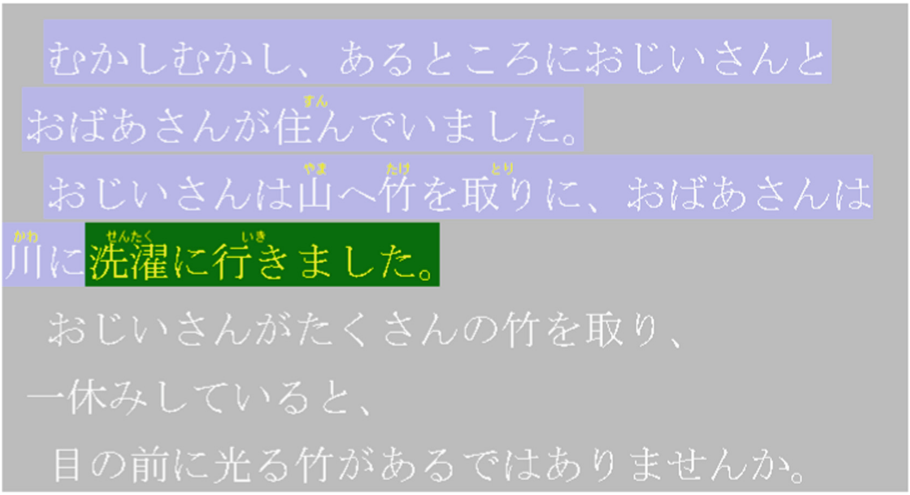

Fig. 9. Presentation example.

5.2 Read Aloud Voice Recognition

We have eight students in our laboratory for the experiments. They include three students that mother tongues are not Japanese. It is easy to measure the strength of the voice of a user in experimental environments. With the voice of a single person, it is difficult to evaluate the precise pronunciations. However, it is easy to evaluate the strength of the voice.

In normal class room, there are many other sounds other than the voice of the user. In the environments, it is not easy to separate the voice among other voices and noises. We use the recorded voice for checking the pronunciations by the teachers.

In the experiment, the new Japanese text presentation system decides about 80 % of the voices as correct pronunciations of the high-lighted parts. This result depends on the threshold. We can tune these results. Figure 10 shows the part of the recognition results. In Fig. 10, ‘mukashimukashi’ is the phonemes of the first part of the text in Fig. 9. The phenomes of a text and the phenomes of a voice are same in Fig. 10.

Table 3 shows the examples of voice recognitions that have some errors. In Table 3, the column ‘Text’ is the correct phonemes of a text. The column ‘Voice’ is the recognized phonemes from the voice reading the text.

At the first row, a long vowel is not recognized. That is represented as ‘:’. At the second row, also a long vowel is not recognized. And, a gap between words is not properly recognized. At fifth row, two phonemes are not recognized properly. At sixth row, a phoneme ‘ri’ is inserted in the result of voice recognition.

The errors as the first row are recovered with the help of the Levenshtein distance. The errors as the second row are difficult to recover in this stage.

5.3 Estimation of User’s Activity

Table 4 shows the analyzed results of users’ activities using phoneme analysis. The subjects are male, and span from 22 years old to 27 years old. The subjects D, G and H are subjects that mother tongs are not Japanese. They can read, write, and speak Japanese well. Other subjects are Japanese. The subject D, G and H need more reading time than other Japanese.

Table 4 shows the experiments of 8 subjects. The correctness in the table is the correct recognition rate of the decision about correctly reading aloud or not. In Table 4, the subjects D, G and H need more silence time than other subjects need. With the utterance analysis, we have much more precise information for understanding the user’s reading activity.

Table 3. Error examples in voice recognition.

#	Text	Voice
1	oji:saNto	ojisaNto
2	oba-saNgasuNdeimashita	obasaNgasuru
3	takeotorini	kakyo:toriniru
4	takeotorini	shibakarini
5	hitoyasumishiteiruto	ichiyasumishiteiruto
6	hitoyasumishiteiruto	hitoriyasumi/shiqteruto

Table 4. Reading time of all subjects.

Subject	A	B	C	D	E	F	G	H
Correctness	0.80	0.60	0.67	0.87	0.87	0.67	0.47	0.47
Reading time (S)	25.1	24.0	26.2	30.2	23.5	28.1	38.1	45.3
Utterance time (S)	21.0	14.5	19.5	20.5	14.0	17.5	15.5	18.0
Silence time (S)	4.1	9.5	6.7	9.7	9.5	10.6	22.6	27.3

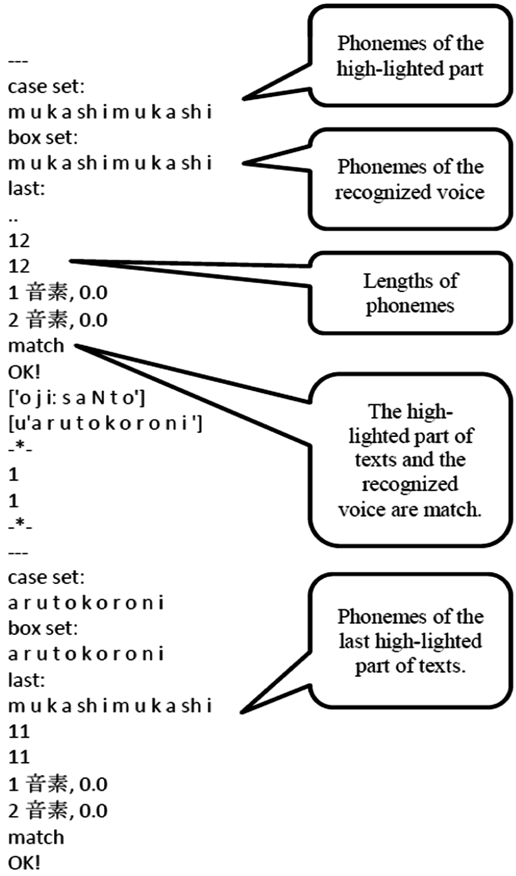

Fig. 10. Phoneme analysis logs.

Figure 11 shows the relations between reading time and the utterance time. In the graph, the vertical measure's unit is second. There are varieties of reading activity. In the graph, the increase in a silence time causes the increase in a reading time. The subject 'A' needs a little silence time. The subject 'H' needs a large silence time. With a long silence time, the reading speed increases.

Reading Profile. At each session, we have the distribution of the length of high-lighted parts and the reading time of the parts from the record of reading activities. Figure 12 shows an example of the distribution. The subject has good reading ability. In Fig. 12, the center line shows a line representing the linear approximation of the distribution of the data. The linear approximation is shown (1).

$$Y = 336.16X + 256.93 \tag{1}$$

In (1), Y is the reading time in 1/1000 s. X is the length of a high-lighted part in the number of characters. The upper line is 1 s increased from the linear approximation.

The lower line is 1 s decrease from the linear approximation. In the example, three data are over the upper line. Removing these three data, we have the distribution shown in Fig. 13. In Fig. 13, all data drop between the upper and lower line. The linear approximation is shown (2).

$$Y = 273.56X + 612.58 \tag{2}$$

Comparing (1) and (2), the slant of the line decreases 20 %. The vertical position of (2) is 0.25 s upper than (1). The reading activity described (2) is the ideal reading activity for the subject.

This linear approximation represents the profile of a subject with two parameters.

5.4 Total Reading Profiles in a Class

Table 5 shows the calculated reading profiles and reading difficulties of pupils of a 4th school years in a school. The value of slant is the 1/1000 s per character. The value of position is 1/1000 s. In the table, it is difficult to understand the distribution of reading activities and reading profiles. In Table 5, there is no difference between the original and the removed without removed data. Removing the outlier data, the slant of the linear approximation of the distribution decreases in many cases. The pair of the parameters representing the linear approximation represents the reading profile of a subject. However, with this table, it is difficult to understand the distributions of the reading profiles of pupils in a class.

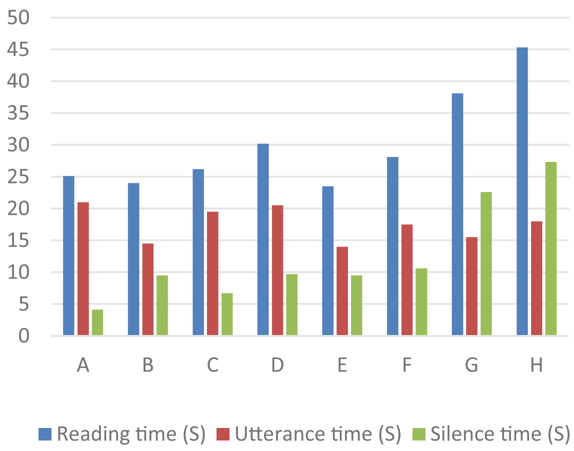

Fig. 11. Reading time and utterance time (Color figure online).

In Table 5, it is difficult to understand the users' profiles. However, we can find some tendency between the sessions with or without outliers. The outlier removed present reading difficulties. The sessions with and without outliers are similar in their averages.

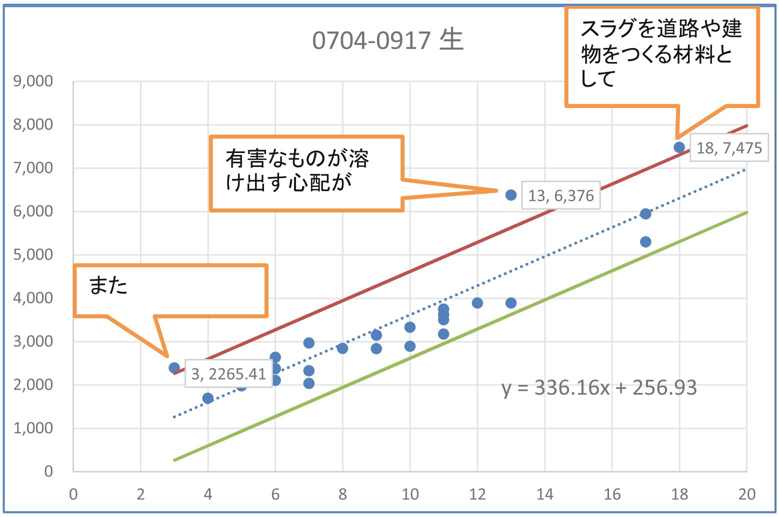

Fig. 12. Distribution of a reading time and the length of a high-lighted part.

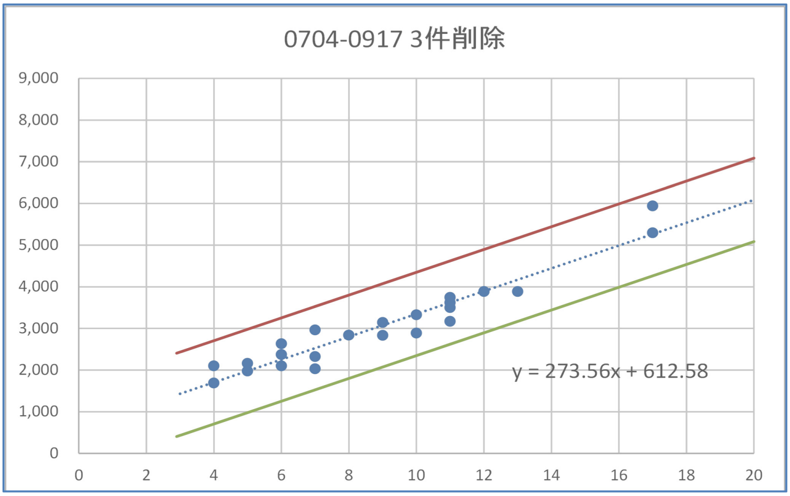

Fig. 13. Distribution of a reading time and the length of a high-lighted part with outlier removal.

The average of pairs of the slant and the position are 192 mS/character and 1714 mS with reading difficulties. The average are 197 mS/character and 1603 mS. Removing outliers, we have the average 176 mS/character and 1844 mS with reading difficulties. Simple averaging shows no apparent difference between the profiles of reading activities with or without reading difficulties. Removing outliers, we can find difference between reading profiles with or without reading difficulties. With reading difficulties, a pupil read 30 % faster than the pupils without a reading difficulty.

Table 5. Profiles of pupils of 4th school years.

Original		Removed		#Removed
Slant	Position	Slant	Position	
208.36	1746.35	208.36	1746.35	0
283.35	846.33	194.32	1417.46	2
246.49	1430.14	246.49	1430.14	0
89.74	2712.02	89.74	2712.02	0
203.41	1974.3	203.41	1974.3	0
151.69	2421.69	222.5	1492.76	1
133.29	1959.85	82.56	2168.9	2
215.13	1807.88	215.13	1807.88	0
128.59	3081.51	178.1	2021.82	3
239.27	1639.15	239.27	1639.15	0
251.8	1484.38	50.21	2758	3
342.98	821.71	252.78	1346.97	1
290.72	1348.89	251.38	1488.28	2
189.84	1969.34	189.84	1969.34	0
130.43	1683.47	116.16	1517.79	2
281.83	1119.22	281.83	1119.22	0
140.59	1863.54	98.2	1933.31	3
130.79	3321.82	71.71	3635.66	2
218.19	2379.57	208.45	2334.76	1
278.99	660.57	135.64	1393.45	4
312.09	605.42	256.59	883.77	2
103.13	1584	71.91	1674.23	2
190.4	2713.75	202.04	2472.69	1
257.17	1220.97	257.17	1220.97	0
104.7	1971.1	150.28	1330.57	1
215.33	1429.22	215.33	1429.22	0
87.24	1585.62	87.24	1585.62	0
87.95	2219.36	65.79	1923.8	3
226.52	1496.41	226.52	1496.41	0
220	1364.88	220	1364.88	0
110.61	1610.71	110.61	1610.71	0
252.5	1628.69	252.5	1628.69	0
84.46	2028.6	84.46	2028.6	0
265.22	1267.01	265.22	1267.01	0
113.82	1399.95	113.82	1399.95	0
231.34	1624.25	231.34	1624.25	0
159.22	2117.51	112.95	2439.37	1
234.14	2126.53	234.14	2126.53	0
125.6	1358.16	125.6	1358.16	0

(*Continued*)

Table 5. (*Continued*)

Original		Removed		#Removed
Slant	Position	Slant	Position	
268.5	1309.41	268.5	1309.41	0
164.32	1570.36	102.43	2000.9	1
239.12	1990.26	248.95	1786.71	1
117.58	1396.86	117.58	1396.86	0
230.07	1495.53	230.07	1495.53	0
208.98	961.59	161.49	1291.92	1
202.73	1695.04	202.73	1695.04	0
133.36	1632.85	84.5	1972.77	1
117.26	2027.91	117.26	2027.91	0
259.62	1742.17	259.62	1742.17	0
99.2	1373.03	99.2	1373.03	0
236.42	1725.11	236.42	1725.11	0
229.58	1504.86	133.79	2022.59	2
277.62	1569.76	277.62	1569.76	0
112.55	2036.83	112.55	2036.83	0
167.74	1313.21	136.43	1408.95	2
281.28	1126.7	281.28	1126.7	0
157.53	815.06	157.53	815.06	0
271.71	1038.99	222.6	1380.65	1
136.45	1462.29	81.04	1847.78	1
237.89	1632.7	237.89	1632.7	0

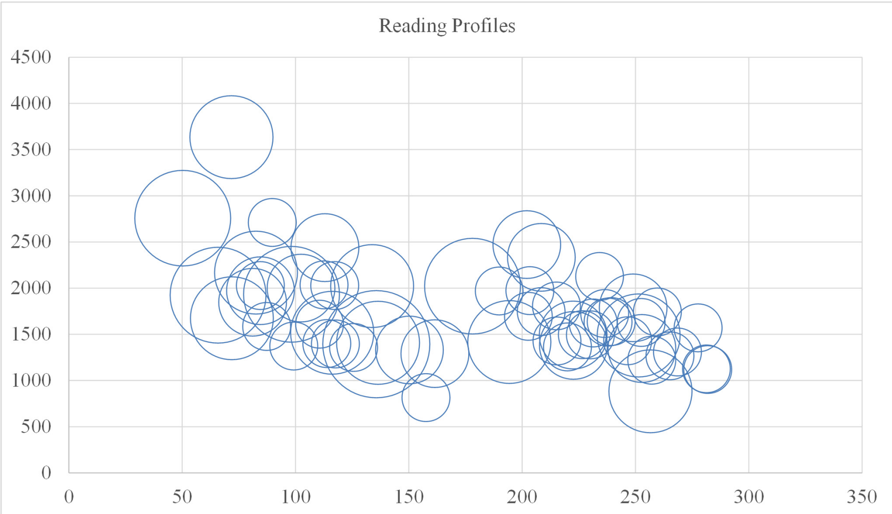

Fig. 14. Reading profiles of pupils of 4th school year.

Figure 14 shows the bubble chart that represents the data in Table 5. In Fig. 14, the size of a bubble represents the number of reading difficulties. The number of reading difficulties is same the number of removed data in Table 5. The horizontal measure represents the slant of the linear approximation. The vertical measure does the vertical position of the linear approximation. The unit of vertical measure is 1/1000 s. The unit of the horizontal measure is 1/1000 s per character. We can find two groups of reading profiles. One type starts slowly and read fast. The other type starts a little faster and read slowly. In Fig. 14, we can understand the position of the reading abilities in a class easily.

6 Conclusion

The proposed new Japanese text presentation system estimates the precise reading activities of the user and the profiles of the users' reading activities from the recorded reading activity logs. The user's reading activity includes not only the key operations of the user, but also the read-aloud voice. We confirm the performance with the experiments.

Using the estimated reading activity, we can estimate the user's state and help the user by the ICT device itself. The estimated users' reading profile helps a teacher to understand the pupils' reading abilities and reading types. It makes the teacher to understand their pupils well. The experiments confirm the performance, and it reveals that we can categorize the reading profiles into two types. One type starts to read slowly and read fast. The other type starts to read fast, and read slowly.

The new Japanese text presentation system enables to work simultaneously in a class room. In a normal class room, a teacher has many pupils, including ones with reading difficulties.

The new proposed system decreases the works of a teacher for using the Japanese text presentation system in a class simultaneously and individually. All of pupils in a class utilize the Japanese text presentation system properly with the help of a teacher and the system itself. A teacher does not need to check all record of the user's reading activities. The system detects the points where the reading difficulty is. This enables easier use of the Japanese text presentation system in normal class rooms. The user's reading profile helps a teacher to understand the pupils' reading behaviors.

To understand the reading profiles, we need much more experiments and discussions with teachers. The much more precise record of the user's activities helps to make the precise understanding of the reading activity with less teacher's work. We will add user guidance function discussing with teachers.

We must discuss about the sequence of a silence time and an utterance time. We must discuss about the two types of reading profiles. These lead us to the more precise understanding of reading activity and reading profile.

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References

1. Kozlovszky, M., Kotcauer, P., Acs, S.: Advanced vulnerability assessment tool for distributed systems. In: Dulea, M., Karaivanova, A., Oulas, A., Liabotis, I., Stojiljkovic, D., Prnjat, O. (eds.) High-Perf. Comp. Infrastr. for South East Europe's Research Communities, Modeling and Optimization in Science and Technologies 2. MOST, vol. 2, pp. 139–146. Springer, Heidelberg (2014)
2. Aoki, K., Murayama, S.: Japanese text presentation system for persons with reading difficulty -design and implementation. In: CSEDU 2012, vol. 1, pp. 123–128, Porto, Portugal (2012)
3. Law. http://www.bunka.go.jp/chosakuken/pdf/tokuteitosyo_fukyu_gaiyo.pdf
4. Murayama, S., Aoki, K., Morioka, N.: Image processing to make teaching aids for learning disability persons. In: IEICE-108, IEICE-WIT-488 (2009)
5. DAISY. http://www.daisy.org/
6. Julius. http://julius.sourceforge.jp/
7. Mecab. https://code.google.com/p/mecab/
8. Pyglet. http://www.pyglet.org/
9. Levenshtein, A.: Binary codes capable of correcting deletions, insertions and reversals. Sov. Phys. Dokl. **10**(8), 707–710 (1966)

Assisting European Portuguese Teaching: Linguistic Features Extraction and Automatic Readability Classifier

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Abstract. This paper describes two automatic systems: a linguistic features extractor and a text readability classifier for European Portuguese texts. Its main goal is to assist the selection of adequate reading materials to support Portuguese teaching, especially as a second language. To the feature extraction from texts, the system uses several Natural Language Processing (NLP) tools. Currently, 52 features are extracted: parts-of-speech (POS), syllables, words, chunks and phrases, averages and frequencies, among others. A classifier was created using these features and a *corpus*, previously annotated readability level, adopting the five-levels language classification official standard for Portuguese as Second Language. In a five-levels (from A1 to C1) scenario, the best-performing learning algorithm (LogitBoost) achieved an accuracy of 75.11 % with a root mean square error (RMSE) of 0.269. In a three-levels (A, B and C) scenario, the best-performing learning algorithm (C4.5 grafted) achieved 81.44 % accuracy, with a RMSE of 0.346.

Keywords: Readability · Readability assessment metrics · Automatic readability classifier · Linguistic features extraction · Portuguese

1 Introduction

The selection of adequate reading materials for educational purposes is an important task for teaching languages, since giving students reading materials that are "too difficult" or "too easy" can both hinder the learning process and demotivate the students [11]. This task implies measuring the *text readability*, or *text difficulty*, which remains today a relevant research topic, and in the case of Portuguese language teaching, it is still performed mostly manually.

This paper presents an automatic classifier for European Portuguese texts, based on a variety of linguistic features. It seeks to assist the selection of adequate reading materials for teaching European Portuguese, especially as a second language, adjusting them to different language proficiency levels. However, assigning

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readability scores to texts is also important in other areas, such as in the production of medical information, tools and software manuals, safety instructions, *etc.*, whose correct interpretation is essential to avoid different types of risk and to make such texts accessible reading to the majority of the population.

The extraction of linguistic features from texts is a core task in the creation of automatic readability classifiers. Text readability is affected, among other factors, both by lexical difficulty (the vocabulary level) and by the syntactic difficulty (the sentence complexity) [16]. This paper presents a system that automatically extracts linguistic features from Portuguese texts and an automatic readability classifier for European Portuguese texts. To accomplish this, the system uses existing Natural Language Processing (NLP) tools, a parser and an hyphenator, and two *corpora*, previously annotated by readability level. Currently, the system extracts 52 features, grouped in 7 groups: parts-of-speech (POS), syllables, words, chunks and phrases, averages and frequencies, and some extra features.

Two experiments were carried out to evaluate the classification task: one based on a five-levels scale (A1, A2, B1, B2, C1), taken from the *Framework for Teaching Portuguese Abroad* (in Portuguese, *Quadro de Referłncia para o Ensino de Portugułs no Estrangeiro*, QuaREPE)[1], published by the Portuguese Ministry of Education and Science [13], and a second experiment based in a simplified three-levels scale (A, B and C).

The paper is organized as follows: first, some related work is presented (Sect. 2), and then the Natural Language Processing tools here used (Sect. 3), followed by the features extracted from the text (Sect. 4), the user interface developed (Sect. 6) and the automatic readability classifier here developed (Sect. 5). Finally, the evaluation (Sect. 7) is presented, followed by the conclusions and perspectives for future work (Sect. 8).

2 Related Work

There are several works on the topic of feature extraction for predicting the readability of documents. For English, early approaches consisted only in measuring simple features like the average sentence length, average number of syllables per word, *etc.* These methods include metrics such as *Flesch Reading Ease* [9], the *Fog Index* [14,15], the *Fry Graph* [10] and the *SMOG* ("Simple Measure of Gobbleygook") [20]. In general, these methods do not take into account the content of documents, which was only later considered for readability metrics, when some systems used a pre-determined list of words to predict the reading difficulty, such as the *Lexile* [24] measure. More recently, language models have been used instead for this task, such as unigram language models, trained to predict the reading difficulty of English documents [25]. Other methods used syntactic features in addition to the language models [23], while some approaches [21]

[1] http://www.dgidc.min-edu.pt/outrosprojetos/data/outrosprojectos/Portugues/Documentos/manual_quarepe_orientador_versao_final_janeiro_2012.pdf (accessed in Dec. 2014).

relied on a variety of linguistic features, namely lexical, syntactic and discourse relations, in order to improve the classification.

Regarding the systems developed for Portuguese that are able to assess the readability of texts based on linguistic features' extraction, one can refer REAP.PT[2] [19] ("REAder-specific Practice for Portuguese"), a tutoring system for European Portuguese vocabulary learning, which has been developed from the REAP system [6] (English). Its readability measurement task is based on lexical features, such as statistics of word unigrams. It achieved an adjacent accuracy of 87.60 % and an RMSE of 0.676 on 10-fold cross validation. LX-CEFR[3] [5] is yet another system to select adequate materials for creating exams for teaching European Portuguese as second language. Its readability measurement task is based on the Flesch Reading Ease formula, frequency of nouns, average syllables per word, and average words per sentence. It achieved an maximum accuracy of 30 % on 10-fold cross validation, while only using the average number of syllables per word in the classification task.

3 Natural Language Processing Tools

To aid the extraction of features from European Portuguese texts, the system uses the natural language processing chain STRING[4] (Statistical and Rule-Based Natural Language Processing chain) [18] to extract statistical information about the texts. The number of syllables is extracted using the hyphenator YAH (Yet Another Hyphenator) [8].

STRING [18] is an hybrid statistical and rule-based natural language processing chain for Portuguese, which has been developed by L2F-Spoken Language Laboratory, at INESC-ID Lisboa. STRING has a modular structure and performs all the basic NLP tasks, namely tokenization and text segmentation, part-of-speech tagging, rule-based and statistical morphosyntactic disambiguation, shallow parsing (chunking) and deep parsing (dependency extraction). For parsing, the system uses *XIP*[5] [1] (Xerox Incremental Parser), a rule-based parser, whose European Portuguese grammar was jointly developed with XEROX.

The YAH Hyphenator [8] is a tool that has been developed by L2F-Spoken Language Laboratory, at INESC-ID Lisboa, originally designed by Ricardo Ribeiro and later improved by Pedro Figueirinha. This is a rule-based system that applies various word processing division rules.

4 Features

The set of 52 features extracted by the system consists in: (i) part-of-speech (POS) tags, chunks, words and sentences features; (ii) verb features and different

[2] http://call.l2f.inesc-id.pt/reap.public (accessed in Dec. 2014).
[3] http://nlx.di.fc.ul.pt/~jrodrigues/camoes/indexLXCENTER.html?exemplo (accessed in Dec.2014).
[4] https://string.l2f.inesc-id.pt (accessed in Dec. 2014).
[5] Reference Guide: https://open.xerox.com/Repo/service/XIPParser/public/XIPReferenceGuide (accessed in Dec. 2014).

metrics involving averages and frequencies; (iii) several metrics involving syllables; and (iv) extra features. The features of group (i) are extracted from the chunking tree generated by STRING; features from groups (ii) and (iv) are also extracted from the chunking tree, but complemented by the dependencies' information generated by the processing chain; the metrics related to syllables (iii) are extracted using YAH. The feature set used is present in appendix section.

For lack of space, only a sketch of the rationale behind these features is provided below; see [7] for details.

The system calculates the part-of-speech (POS) relative percentages. Conceptual information, often introduced through nouns and named entities, *e.g.* peoples names, locations, organizations, *etc.*, is important in text comprehension, yet the more entities and types of entities a text has, the harder it is to keep track of them and of the relations between them.

Statistics about elementary syntactic constituents (or chunks: nominal phrases - NP, prepositional phrases - PP, *etc.*) are also extracted. Auxiliary verb chunks [2] can combine among them to form longer, complex verbal chains: the longer the chain, the more complex is the decoding of the grammatical values involved. Subclause chunks are related to sentence hypotaxis complexity [3], while the number of coordination relations and the length of their chains are related with the parataxis complexity.

The length of a text is related with its readability, *i.e.* typically, longer texts, specially with long sentences, have much more detail or content, which can make them more difficult to understand. Word frequency is related to the vocabulary use and, according to [25], it can affect the readability of a text: texts with more familiar vocabulary are easier to understand by the reader. Word frequency has been captured by way of a unigram-based language model, defined by:

$$\sum_{w} C(w) \times log(P(w|M)) \tag{1}$$

where $P(w|M)$ is the probability of word w according to a background *corpus* M, and $C(w)$ is the number of times w appears in the text. This model will be biased in favor of shorter texts. Since each word has probability less than 1, the log-probability of each word is less than 0, and hence including additional words decreases the log-likelihood. To overcome this issue, the system calculates this probability in n groups of 50 words each and then calculates an average of the n results. The calculations were performed using Laplace smoothing over the word frequencies, obtained from a set of several, distinct European Portuguese *corpora*, provided by the AC/DC project and available at Linguateca.

Based on previous statistics, the system then extracts several averages and frequencies. The frequency of nouns is the ratio of the number of nouns per number of words, and a similar ratio is calculated for the verbs. The average number of verb phrases per sentence and the average length of sentences derive from Pitler and Nenkova [21]: the more verbs a sentence contains and the longer a sentence is, the more complicated it becomes to understand it. The average length of syllables per word is deemed important for readability metrics such as the Flesch Reading Ease and others metrics (see Sect. 2).

Table 1. Corpus distribution.

	A1	%	A2	%	B1	%	B2	%	C1	%	Total
# Text	29	12.2	39	16.5	136	57.4	14	5.9	19	8.0	237
# Sentences	184	11.9	384	24.7	535	34.5	199	12.8	250	16.1	1 552
# Words	2,655	10.3	5,010	19.4	9,407	36.3	3,702	14.2	5,114	19.8	25,888

The number of pronouns per noun phrases derives from CohMetrixPort system [22]. The greater the number of pronouns per noun phrases, the more difficult it becomes to identify whom or what the pronoun refers to. The use of NP with a definite or demonstrative determiner usually implies a process of reference resolution, as opposed to indefinite determiners, which do not refer to previously occurring words. A text with lower definite/indefinite NP ratio should be more cohesive, hence the anaphora processing involved renders its decoding more difficult.

The feature extraction system was evaluated on a manually annotated text, with 490 words and 14 sentences taken from journalistic texts. For lack of space detailed analysis can not be made here. The system achieve 98.81 % of precision, 98.88 % recall and a F-measure (F) of 98.85 %.

The feature set is largely language-independent, though some features require adequate NLP tools (e.g. chunking), while others depend on the morphosyntactic properties of the language (*e.g.* auxiliary verb types). Specific language-dependent features, to be explored in future work, relate mostly to syntactic dependencies (*e.g.* modifier, adjunct), but they can be approximated using broad interpretation of those relations.

5 Readability Classifier

According to the Framework for Teaching Portuguese Abroad (in Portuguese, *Quadro de Referłncia para o Ensino de Portugułs no Estrangeiro*, QuaREPE) [13], published by the Ministry of Education and Science, and based on the international standards of the European Common Reference Framework for Languages, it is considered that the degree of proficiency in a foreign language can be determined on a scale of five-levels: A1: initiation; A2: elementary; B1: intermediate; B2: upper intermediate; and C1: advanced.

The system's performance on the classification task was evaluated with two experiments: one based on this five-levels scale and a second experiment based on a simplified three-levels scale, *i.e.*, the classifier is trained to predict if the text belongs to level A, B or C. This second experiment is useful because distinguishing between the levels A1 and A2, or between B1 and B2, may be very difficult, even for a specialist.

The *corpus* used to train the classifier consists of a set of 237 texts, provided by the Instituto Cames[6] and previously classified according to their readability.

[6] http://www.instituto-camoes.pt (accessed in Dec. 2014).

This *corpus* was created from tests, exams and materials used for teaching European Portuguese as a foreign language. The manual text readability classification takes into account reading and comprehension skills stipulated by the QuaREPE for each level. Table 1 shows the *corpus* distribution for each readability level. One should bear in mind that the uneven distribution and the small size of some classes (and of the *corpus* as a whole), are likely to have an impact on the classifier, which is unavoidable due to the scarcity of resources for this task.

6 User Interface

The two systems here presented have been made available to the general public through a web-based interface[7] (Fig. 1). In the classification task, the user can choose the classifier more adequate to his/her goals: the five-levels scale (A1, A2, B1, B2, C1) or the simplified three-levels scale (A, B and C). This systems can easily be extended by adding new features or metrics of interest to the task at hand.

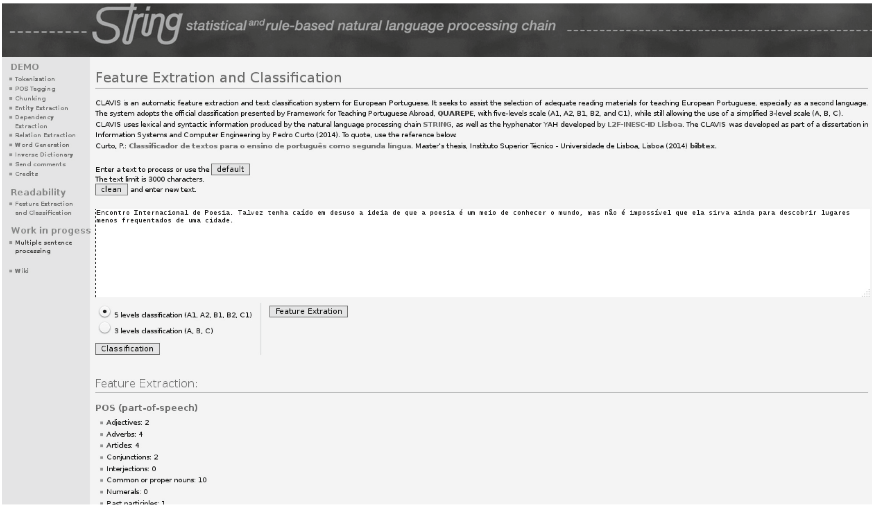

Fig. 1. Linguistic feature extraction system.

In the results of the classification system (Fig. 2), the readability level predicted by the classifier also shows the linguistic features information extracted from the text used in the classification process. In order to ease the interpretation and analysis of those results, each linguistic feature is represented with a graphic bar that frames the feature values according to the maximum value observed in the training set of texts used. This bar was three different colors depending on the value reached by the feature, *i.e.*, green color when the percentage achieved is less than 34 % of the maximum observed value, yellow if between 34 % and 68 %, and red when it is higher than 68 %.

[7] https://string.l2f.inesc-id.pt/demo/classification.pl (accessed in July 2015).

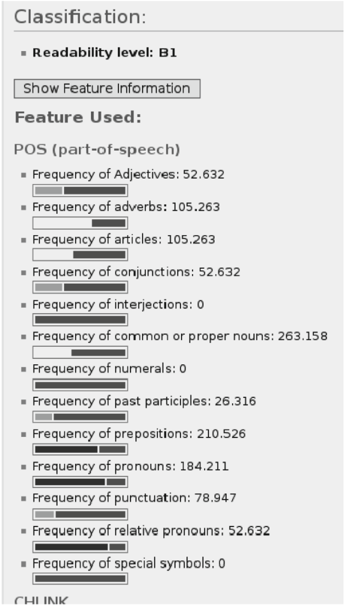

Fig. 2. Readability classification system results.

7 Evaluation

7.1 Readability Classifier

In both scenarios, several machine learning algorithms available in WEKA machine learning toolkit[8] [4] were tested (Tables 2 and 5). The evaluation was performed using 10-fold cross-validation. The metrics chosen for measuring the performance of the classifier were accuracy (percentage of correctly classified instances), root mean square error (RMSE), ROC area and Kappa statistics. Additionally, a confusion matrix and algorithm performance comparison are presented for each scenario.

Five-Levels Classification. The best-performing learning algorithm was the *LogitBoost* (Table 2).

In this scenario, we also considered the *adjacent accuracy within 1 grade level* as a useful evaluation metrics. This is the percentage of predictions that are equal to or show one level of difference to the manually assigned level. Measuring strict accuracy is considered too demanding because manually assigned labels are not always consistent.

[8] http://www.cs.waikato.ac.nz/ml/weka (accessed in Dec. 2014).

Table 2. Algorithms comparison results (five-levels classifier).

Algorithms	Accuracy	RMSE
Naive Bayes	68.35 %	0.339
Support Vector Machines	70.04 %	0.342
Logistic regression	59.07 %	0.402
K-nearest neighbors learner	65.40 %	0.368
K*	70.04 %	0.339
AdaBoost	59.49 %	0.360
LogitBoost	**75.11%**	**0.269**
Holte's OneR	69.20 %	0.351
C4.5	71.31 %	0.323
C4.5 grafted	72.57 %	0.319
Decision stumps	61.18 %	0.297
Random Forest	70.04 %	0.275

Table 3. Evaluation of the readability classifier (five-levels).

Accuracy	RMSE	ROC Area	Kappa	Adjacent Acc
75.11 %	0.269	0.918	0.590	91.98 %

The five-levels classification (Table 3) correctly classified 75.11 % instances, *e.g.*, 178 texts. It is interesting to notice that for most texts, the assigned level is either correct or mostly within one-level difference (Table 4). As expected, the adjacent accuracy is very high (91.98 %) and the RMSE result is low because the expected and the observed values are close. The Kappa metric is a chance-corrected measure of agreement between the classifications and the expected values, where 1.0 represents perfect agreement. The Kappa value obtained (0.59) corresponds to a *moderate agreement*, according to [17].

Table 4. Confusion matrix (five-levels).

		Predicted class				
		A1	A2	B1	B2	C1
Actual class	A1	18	7	4	0	0
	A2	2	27	10	0	0
	B1	5	4	121	1	5
	B2	0	0	4	2	8
	C1	0	1	4	4	10

Three-Levels Classification. In this scenario, the best-performing learning algorithm was the *C4.5 grafed* (Table 5), with a 81.44 % accuracy and 0.346 RMSE. The second best algorithm, and with very similar results, was the *LogitBoost*, which achieved a lower accuracy than the *C4.5 grafed* (80.17 %) despite having a lower RMSE value (0.294). Since, in this scenario, the scale used has only 3 levels, the RMSE value was considered less significant than the accuracy value.

Table 5. Algorithms comparison results (three-levels classifier).

Algorithms	Accuracy	RMSE
Naive Bayes	75.11 %	0.405
Support Vector Machines	75.11 %	0.363
Logistic regression	70.46 %	0.439
K-nearest neighbors learner	72.15 %	0.428
K*	77.22 %	0.385
AdaBoost	68.78 %	0.352
LogitBoost	80.17 %	0.294
Holte's OneR	73.84 %	0.418
C4.5	80.17 %	0.352
C4.5 grafted	**81.44 %**	**0.346**
Decision stumps	70.89 %	0.347
Random Forest	79.75 %	0.295

Table 6. Evaluation of the readability classifier (three-levels).

Accuracy	RMSE	ROC Area	Kappa
81.44 %	0.346	0.831	0.639

The three-levels classification (Table 6) achieved a better accuracy (86.32 %) and obtained RMSE and ROC area values similar to the previously mentioned classifier. In this scenario, the adjacent accuracy was not calculated. However, it is important to report that for all the texts corresponding to A or C levels, the level assigned is correct or within one-level difference (Table 7). The Kappa value obtained (0.639) corresponds to a *substantial agreement*, according to [17].

7.2 Feature Contribution

To assess the contribution of the features extracted for the readability classification, we used the WEKA toolkit [4] with the feature selection algorithm

Table 7. Confusion matrix (three-levels).

		Predicted class		
		A	B	C
Actual class	A	57	11	0
	B	12	127	11
	C	0	10	9

InfoGainAttributeEval[9]. This evaluation was conducted in the two different, previously mentioned scenarios (Sect. 5). Figures 3 and 4 show the results for the features with higher contribution on the classification task.

Regarding the five-levels classification (Fig. 3), among the top five features, some are computationally simple to obtain, namely the number of words (0.94), of different words (0.93), and sentences (0.54), showing the relevance of more traditional readability metrics. On the other hand, the number of dependencies (0.85) and the total number of nodes (0.64) result from the processing chain and justify the use of more sophisticated, NLP-based tools in this classification task. The remaining parameters are related to the POS groups (frequency of adverbs), phrases (frequencies of past participle verb phrases - VPASTPART, temporal auxiliary verb phrases - VTEMP, infinitive verb phrases - VINF, copulative verb phrases - VCOP and PP), and averages and frequencies (average of coordinating relations' chains, frequency of words with 1–4 syllables and average

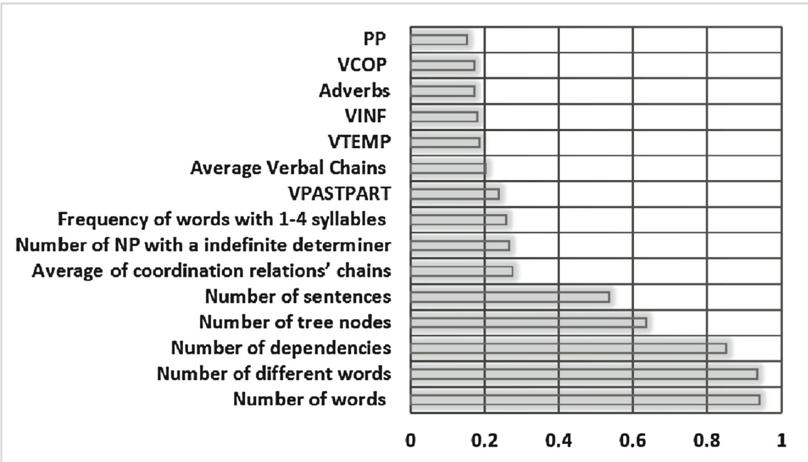

Fig. 3. Feature contribution for the five-levels scale classification.

[9] http://weka.sourceforge.net/doc.stable/weka/attributeSelection/InfoGainAttributeEval.html (accessed in Dec. 2014).

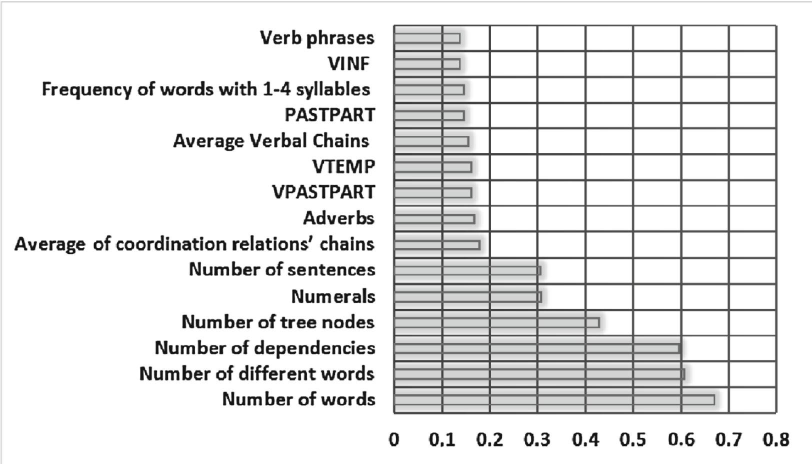

Fig. 4. Feature contribution for the three-levels scale classification.

of verbal chains), and extra features (number of noun phrases - NP - with indefinite determiners).

In the three-levels classification (Fig. 4), the features that contributed most to the success of the classifier were: the number of words (0.67), of different words (0.61) and of dependencies (0.60). Again, this last feature highlights the importance of using a more sophisticated NLP-based tool than just simple counts of words and sentences length for the classification task. For example, the list of fifteen features that stood out in the success of the two classifiers is very similar

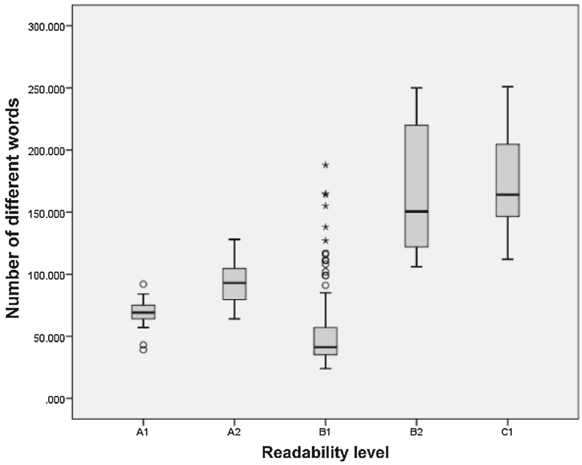

Fig. 5. Number of different words value variations between the different readability levels.

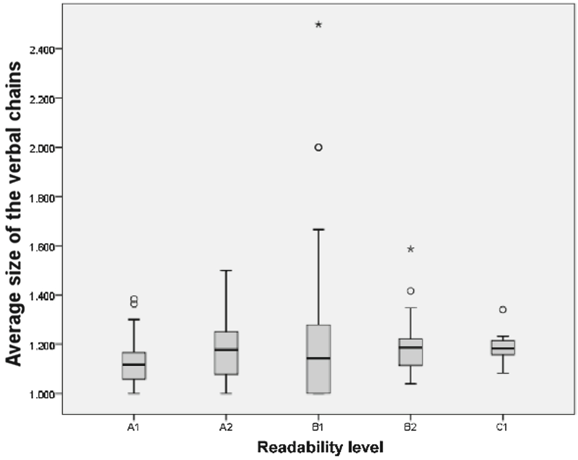

Fig. 6. Average size of the verbal chain value variations between the different readability levels.

(Spearman correlation coefficient of 0.881), only changing the priority order of some features. The 1–4 syllables word frequency parameter was not so relevant to the results of the tree-levels scenario (0.14) as it was in the five-levels scenario (0.26).

Additionally, box plot diagrams were built for each feature used, which allowed to analyse feature value variations between the different readability levels. Given the large number of diagrams, only two examples are presented here, namely, the one referring to the number of different words (Fig. 5) and another on the average of verbal chain's (Fig. 6). By analysing the box plot diagrams, it was possible to conclude that there is no feature that has completely different values for each readability level and, on the features with highest contribution such as the one on Fig. 5 (0.93 in the five-levels and 0.61 on the three-levels scale classification), we observe that the B1 level has texts that seems to belong to A1 and A2 levels. However, the remaining features (with lowest contribution), like the average size of the verbal chain (Fig. 6), do not have a distinct values range between different readability levels. These observations confirm the complexity of the text readability classification task.

8 Conclusions and Future Work

This paper presented two classifiers for European Portuguese texts based on a variety of linguistic features. These classifiers seek to assist the selection of adequate reading materials for teaching European Portuguese as a second language adapted to different language proficiency levels.

The feature system focused on 52 features, from simple word counts to complex syllables and word-length counts, and rather sophisticated data involving parsing techniques. The feature extraction achieved 98.85 % F-measure, which is quite satisfactory.

A study of the features that contributed most to the success of the classification task was conducted. For both classifiers, the feature contribution shows the importance of using more sophisticated, NLP-based tools in this classification task. Additionally, the complexity of the classification task was shown by the analysis of the feature value variations between the different readability levels.

In both scenarios, with five readability levels (A1 to C1) or with three levels (A, B or C), the classifiers here developed achieved good results with an accuracy of 75.11 % and 81.44 %, respectively, and most of their errors are within one-level distance from the expected results. For comparative purposes, the five-levels classifier developed presents good results against the best classifier of the LX-CEFR system [5] (Sect. 2), which just got a maximum accuracy of 30 %, while only using the average number of syllables per word in the classification task. For evaluation purposes, the *corpus* used in the classifiers here presented is the same used by LX-CEFR system but with 112 additional texts.

The systems here presented have already been made available to the general public through a web form[10] and they can easily be extended by adding new features or metrics of interest to the task at hand. Taking into account the small size of the *corpus* annotated according to the readability level in the five-level scale defined by QuaREPE [12], it may prove useful to investigate unsupervised learning techniques, *i.e.* techniques that do not depend on a previously classified *corpus*, for example, using techniques of cluster analysis, which allows to group a set of objects into clusters via their similarities.

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Appendix

The list of features used in the classification task are presented in Table 8. For the classification task, the features' values for the parts-of-speech, chunks, verbs and extras groups (with the exception of total number of dependencies, total number of tree nodes and number of pronouns per NP) are represented by a ratio weighted by number of words divided by 1000. For example, the adjectives' feature is calculated as follows: number of adjectives/(number of words/1000).

For the verbs group of features, the system considers the different inflected verbs forms as independent counts to measure the use of different tenses and verb forms. The special symbols are, for example, "$", "%", "#", *etc.*

[10] https://string.l2f.inesc-id.pt/demo/classification.pl (accessed in March 2015).

Table 8. Features used in classification.

Group	Features
Part-of-speech (POS)	Adjectives (ADJ)
	Adverbs (ADV)
	Articles (ART)
	Conjunctions (CONJ)
	Interjections (INTERJ)
	Nouns (NOUN)
	Numerals (NUM)
	Past participles (PASTPART)
	Prepositions (PREP)
	Pronouns (PRON)
	Punctuation (PUNCT)
	Special symbols (SYMBOL)
Chunks	Nominal phrases (NP)
	Adjectival phrases (AP)
	Prepositional phrases (PP)
	Adverbial phrases (ADVP)
	Temporal auxiliary verb phrases (VTEMP)
	Aspectual auxiliary verb phrases (VASP)
	Modal auxiliary verb phrases (VMOD)
	Copulative verb phrases (VCOP)
	Past participle verb phrases (VPASTPART)
	Gerundive verb phrases (VGER)
	Infinitive verb phrases (VINF)
	Finite verb phrases (VF)
	Sub-clause phrases (SC e REL)
	Verb phrases (VF e VCOP)
Sentences and words	Number of sentences
	Number of words
	Number of different words
	Words frequencies
Verbs	Number of different verbs forms
	Number of auxiliary verbs
	Number of main verbs
Averages and frequencies	Average number of verb phrases per sentence
	Average length of sentences
	Average length of syllables per word
	Average size of verbal chains
	Average size of coordination relation's chains
	Frequency of verbs
	Frequency of words with 1–4 syllables
	Frequency of words with more than 4 syllables
Extras	Total number of dependencies
	Total number of tree nodes
	Number of pronouns per noun phrases (NP)
	Number of NP with a definite or demonstrative determiner
	Number of NP with a indefinite determiner
	Number of subordinate clauses (SC/REL chunks)
	Number of coordination relations
	Number of omit subjects
	Flesch Reading Ease BR readability measure

References

1. Aït-Mokhtar, S., Chanod, J.P., Roux, C.: Robustness beyond shallowness: incremental deep parsing. Nat. Lang. Eng. **8**(3), 121–144 (2002). http://dx.doi.org/10.1017/S1351324902002887
2. Gomes, F., Baptista, J., Mamede, N.: Auxiliary verbs and verbal chains in European Portuguese. In: Pardo, T.A.S., Branco, A., Klautau, A., Vieira, R., de Lima, V.L.S. (eds.) PROPOR 2010. LNCS, vol. 6001, pp. 110–119. Springer, Heidelberg (2010)
3. Beaman, K.: Coordination and subordination revisited: syntactic complexity in spoken and written narrative discourse. In: Tannen, D. (ed.) Coherence in Spoken and Written Discourse, vol. 12, pp. 45–80. Ablex, Norwood (1984)
4. Bouckaert, R.R., Frank, E., Hall, M., Kirkby, R., Reutemann, P., Seewald, A., Scuse, D.: WEKA Manual for Version 3-7-11, Hamilton, New Zealand (2013). http://www.cs.waikato.ac.nz/ml/weka/documentation.html
5. Branco, A., Rodrigues, J., Costa, F., Silva, J., Vaz, R.: Rolling out text categorization for language learning assessment supported by language technology. In: Baptista, J., Mamede, N., Candeias, S., Paraboni, I., Pardo, T.A.S., Volpe Nunes, M.G. (eds.) PROPOR 2014. LNCS, vol. 8775, pp. 256–261. Springer, Heidelberg (2014)
6. Brown, J., Eskenazi, M.: Retrieval of authentic documents for reader-specific lexical practice. In: Proceedings of InSTIL/ICALL Symposium 2004, vol. 17, pp. 25–28, Venice, Italy (2004)
7. Curto, P.: Classificador de textos para o ensino de português como segunda língua. Master's thesis, Instituto Superior Técnico - Universidade de Lisboa, Lisboa, October 2014
8. Figueirinha, P.: Syntactic REAP.PT: exercises on word formation. Master's thesis, Instituto Superior Técnico - Universidade de Lisboa, Lisboa, October 2013
9. Flesch, R.: Marks of Readable Style: A Study in Adult Education (Contributions to education), No. 897, Columbia University, Teachers College, Bureau of Publications, New York, United States (1943). http://books.google.pt/books?id=JSIWAAAAIAAJ
10. Fry, E.: A readability formula that saves time. J. Reading **11**(7), 513–578 (1968)
11. Fulcher, G.: Text difficulty and accessibility: reading formulae and expert judgement. System **25**(4), 497–513 (1997). http://www.sciencedirect.com/science/article/pii/S0346251X97000481
12. Grosso, M.J., Soares, A., de Sousa, F., Pascoal, J.: QuaREPE - Quadro de Referência para o Ensino de Português no Estrangeiro. Ministério da Educao e Ciência/Direo Geral de Inovao e Desenvolvimento Curricular, Documento Orientador, Lisboa (2011)
13. Grosso, M.J., Soares, A., de Sousa, F., Pascoal, J.: QuaREPE - Quadro de Referência para o Ensino de Português no Estrangeiro. Tarefas, Actividades, Exercícios e Recursos para a avaliao, MEC/DGIDC, Lisboa (2011)
14. Gunning, R.: The Technique of Clear Writing. McGraw-Hill, New York (1952). http://books.google.pt/books?id=ofI0AAAAMAAJ
15. Gunning, R.: The FOG index after twenty years. J. Bus. Commun. **6**(2), 3–13 (1969)
16. Klare, G.: The Measurement of Readability. Iowa State University Press, Ames (1963)

17. Landis, J.R., Koch, G.G.: The measurement of observer agreement for categorical data. Biometrics **33**, 159–174 (1977)
18. Mamede, N., Baptista, J., Diniz, C., Cabarrão, V.: STRING: an hybrid, statistical and rule-based natural language processing chain for Portuguese. In: Proceedings of the 10th International Conference on Computational Processing of Portuguese (PROPOR 2012), Demo Session, Coimbra, Portugal (2012). https://string.l2f.inesc-id.pt/w/index.php/Publications
19. Marujo, L., Lopes, J., Mamede, N., Trancoso, I., Pino, J., Eskenazi, M., Baptista, J., Viana, C.: Porting REAP to European Portuguese. In: Proceedings of SLaTE 2009, pp. 69–72. Wroxall Abbey Estate, Warwickshire, England (2009)
20. McLaughlin, G.H.: SMOG grading: a new readability formula. J. Reading **12**(8), 639–646 (1969)
21. Pitler, E., Nenkova, A.: Revisiting readability: a unified framework for predicting text quality. In: Proceedings of EMNLP 2008, pp. 186–195. ACL, Stroudsburg (2008). http://dl.acm.org/citation.cfm?id=1613715.1613742
22. Scarton, C.E., Aluísio, S.M.: Análise da inteligibilidade de textos via ferramentas de Processamento de Língua Natural: adaptando as métricas do Coh-Metrix para o Português. Linguamática **2**(1), 45–61 (2010)
23. Schwarm, S.E., Ostendorf, M.: Reading level assessment using support vector machines and statistical language models. In: Proceedings of ACL 2005, pp. 523–530. ACL, Stroudsburg (2005)
24. Stenner, A.J.: Measuring reading comprehension with the Lexile framework. In: Fourth North American Conference on Adolescent/Adult. Academic Press Ltd, London (1996)
25. Thompson, K.C., Callan, J.P.: A language modeling approach to predicting reading difficulty. In: Proceedings of NAACL 2004, pp. 193–200. ACL, Boston (2004). http://www.cs.cmu.edu/~callan/Papers/hlt04-kct.pdf

A Framework for Designing On-line Listening Activities for Postsecondary Music Courses: What Students' Performance and Perceptions Tells Us

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Abstract. Experiencing close listening of music selections in introductory postsecondary music courses is fraught with obstacles in the classroom environment that degrade the learning experience. To address this problem, two types of on-line delivered listening activities were designed based on theories in music cognition and knowledge acquisition. After completing demographic and prior experience questionnaires, students completed (1) a series of self-paced, independent on-line listening activities with guiding comments and questions about basic musical elements, and (2) a peer-led discussion within an avatar-based 3D virtual environment. In the self-paced environment, we collected and analysed students' time on task, page revisitation and accuracy scores. The results indicated that none of the prior experience measures (music experience, computer experience or self-regulation levels) predicted any of the outcome variables. We then analysed the survey results for both activities that asked students to characterize their perceptions of these technology-delivered experiences. Students' perceptions of the worth of the self-paced listening activities were dependent on their level of self-regulation, that is, students with high self-regulation scores, rated the activities lower than those with low or intermediate self-regulations scores. No differences in perception of worth were found in the subsample that experienced both types of activities.

Keywords: Music education · On-line · Listening · Cognitive framework · Higher education

1 Context and Background

The question that animates this study is how to support students in post-secondary music courses to develop the skills to listen to music and to communicate what they hear. Close listening requires active participation and its practice cannot be taken for granted; neither can an understanding of what one is hearing be assumed to be universal. In this paper, we explore the cognitive processes required to make explicit the musical elements that

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are understood implicitly and we consider ways of using technologies to support close listening practice. In articulating this question, we are cognizant of the issues facing undergraduate music education: pressures on the amount of time available for face-to-face contact and increasing competition for the inclusion of a wide range of musical styles in order to engage students in their learning. Such issues stem at least in part from the apparent democratization of post-secondary classrooms in which multiple interests, varied cultural backgrounds, and uneven prior experiences with musical materials compete for time and place.

The study of music suffers greatly in the contemporary classroom. In response to the need to incorporate a cross-section of musical styles, genres, and contexts in our institution, we have redesigned the music history curriculum to emphasize core competencies rather than follow traditional models of chronological, narrative, and style-specific curricula. Gone are the days of presenting a survey of 400 years of (only) classical music to first year music majors, and in its place are courses that teach students to listen – to traditional, popular, and classical musical works in the context of their creation and performance and as comprehensive exemplars of particular times and places. Close listening, arguably the foundation of all music study, serves as the basis for this redesigned curriculum, and it strives to engage students more deeply in the musical examples themselves, allowing instructors to work with students more meaningfully to develop the skills to communicate what they hear and how they understand its significance. A shift to competency-based learning and the premise of complex cultural contexts has required a reconsideration of what and how we present materials for study in and outside of the classroom.

The primary challenges in teaching music listening in 21st century post-secondary environments are related to the time and space of student-instructor interaction. Contemporary students, for whom music is largely background to their daily activities – a soundtrack, if you will – first need encouragement to move music to the foreground of their thoughts, then to learn to describe what they are hearing, and finally to develop the critical thinking capacities to imagine cross-cultural meaning. First year classes of 50–250 students are particularly difficult places to focus such individual and experiential listening and discussion: competing sounds and movement in classrooms, lack of familiarity with the diversity of musical styles, and the rigid timetabling of institutional programs result in very little music being played in class and very little time allocated to discussion and feedback. Lecture-style presentation and testing based on the memorization of selected (i.e., pre-programed) musical concepts is therefore the norm. And despite myriad opportunities for listening outside the classroom, few students take advantage of it unless the instructor is involved. With guidance, early stages of close listening such as are considered here assists students in understanding and connecting specialized terminology to music, in comprehending graphic notation and other documentation of cultural matter, and in hearing the complexity of formal structures and the organization of sounds across musical time. Lastly, a general discomfort with expressing subjective responses frequently keeps the majority of students from participating in open discussion. As Long et al. [10] report, increased opportunities for peer-observation and interaction assist students in developing the skills for future involvement in musical activities (696).

Studies in music cognition [7] indicate that individuals possess far greater understanding of what they hear than they believe, suggesting that what is needed in music education is to find appropriate methods to assist students in bringing their innate knowledge to the surface.

In seeking to develop such confidence in students, the challenges of classroom learning must be addressed. Therefore, in this study we propose to resolve some of them by employing educational technologies and a blended delivery format to extend the classroom and invite individual interaction with materials, guiding students into group discussions of ever more complex cultural environments. The problems of insufficient class time to listen to longer musical examples and limited discussion opportunities are met with multiple asynchronous activities; the distractions of classroom sounds and movement are resolved through the potential for direct input of the music through headphones; the challenge of a vast historical and stylistic content is resolved by increasing the quantity and type of materials included in activities; and the enhanced capabilities of technology allow music to be situated alongside other cultural objects, including video and expressions of other art forms, to establish its place within specific cultural contexts. Finally, in our multicultural classrooms, the lack of a common ground of musical experience is increasingly evident; the activities created in the multiple technical and musical contexts emphasized in this study are designed to allow students to move from the personal to the communal, and to come full circle back towards a common understanding of the role of music in their own world.

2 The Cognition of Listening

To ensure a solid cognitive foundation for our listening activities, we reviewed the literature on music cognition. Honing [7] contends that humans possess an inborn ability to hear certain patterns in music such as the meter or beat of the music as well as to distinguish one melody from another (relative pitch).

Starting from infancy, humans experience the music of their own culture and develop their implicit knowledge of it over time, relying on these innate abilities, become adept at distinguishing common patterns and aspects of music that are distinct to their cultural setting. However, Honing asserts that this accumulated knowledge is not accessible to the conscious cognitive system. People are generally unaware they possess these skills and are not able to consciously draw on or report such knowledge. This is referred to as implicit knowledge.

Honing also contends that people with no training in music are not substantially less able to detect these basic elements than those who possess considerable musical expertise. The difference is that this knowledge is explicit in experts, that is, they are aware they possess it, and are able to report such knowledge, allowing them to share their interpretations of the music to which they are listening. Hence, music education for introductory students should provide scaffolded listening opportunities which help them become aware of their implicit knowledge, thereby transferring it to explicit and sharable knowledge.

3 A Cognitive Framework for Guided Listening

From a theoretical perspective, the need to shift implicit knowledge to explicit knowledge most closely aligns with the concepts described in Karmiloff-Smith's Representational Redescription Model (RR Model) of knowledge acquisition [8]. Through a process she refers to as redescription, implicit knowledge is transformed into explicit knowledge through four phases: Implicit Level (I), Explicit Level One (E1), Explicit Level Two (E2), and Explicit Level Three (E3).

In Implicit Level (I), individuals possess knowledge they have accumulated over time that is not available to their conscious awareness but allows them to respond correctly to external stimuli in their environment. In introductory music courses, this would be evidenced when students are able to answer questions about basic musical elements such as meter (e.g., is this music metric or non-metric?)

The second level, Explicit Level One (E1), furthers the process of redescription when the student begins to be able to make comparisons between two pieces of music.

Students are then scaffolded into Explicit Level Two (E2) through the process of feedback during their listening experience. Through a sequence of listening to multiple pairs of pieces and being tutored on the terms used to describe the differences they are hearing, students begin to acquire the terminology that will help them discuss the musical nuances they are able to detect.

In Explicit Level Three (E3), the students are conscious of and able to consider multiple forms of the material. They can hear differences in the music, describe these differences with commonly understood terms or diagrams and develop the skills needed to follow musical notation. Finally, students are also able to contextualize this material in a specific cultural space and time. Elements of the music can be tied to the socio-political influences of a specific point in history (A sample statement might be: "The [melody, harmony, rhythm, or timbre] you hear at the beginning of this piece is very typical of [a particular person, place, genre, etc.] and reflects the [music, dance, culture, politics, etc.] of that time.) At E3, verbal interactions with others is critical toward developing a complex understanding of how these multiple forms of information fit together.

4 Technologies to Deliver the Cognitive Framework for Guided Listening

Each of these four phases suggests activities that students must experience to move through each phase. To create our supplemental on-line listening activities, we sought the technologies that could best deliver each set of activities.

We began our guided listening activities at *Implicit Level (I)* using the software *Articulate Storyline* which allows for the creation of interactive presentations with quiz features and audio capacity. Within each slide, students can click, hover over, or drag any object to trigger an action. With *Articulate*, we created multiple auditory presentations of music pairs that allowed students to listen to, respond, and receive new information, listen again, respond, etc. until they were able to detect specific musical elements such as meter and rhythm. This activity gives students practice in drawing on the implicit knowledge they already possess to detect basic elements of the music they hear.

The activity is done independently, and with individual results so students can develop their listening skills without being inhibited by being observed. Students can complete some of the activity and return later to complete the rest. The Articulate Storyline interface is visually simple to allow students to attend to the music examples without distractions from a complex visual interface. The features are simple to use and limited in number to encourage the focus to be on the listening rather than the interface itself. Across the two Articulate modules, students were presented with increasingly more difficult questions. For incorrect answers, students received feedback and suggestions for listening (e.g., "That is incorrect. Listen again, is there a beat you can tap your finger to?"). The Articulate activities represent the first set of on-line listening activities that we developed and targets transitions from Implicit Level (I) to Explicit Level one (E1) (Fig. 1).

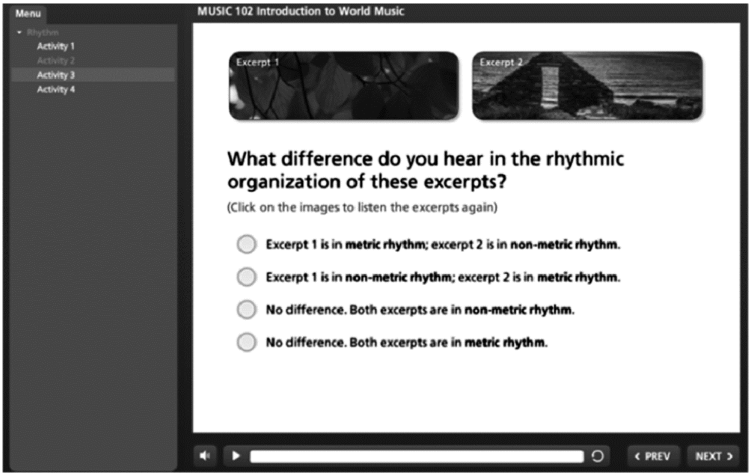

Fig. 1. Sample of Articulate activity - identifying musical elements: listen and answer questions on differences in melody, harmony, rhythm, timbre, and texture.

To transition from E1 to E2, opportunities to begin to label and share listening experiences are necessary. To promote this transition, we suggest instructor-guided discussion in smaller groups delivered via a conferencing system such as Elluminate or Adobe Connect. This will allow for students to ask questions and give responses in much smaller groups than in the large classroom without the need for multiple physical breakout spaces (Fig. 2).

For the final transition to E3, experiencing multiple forms of information is needed to help students contextualize their listening experience in the cultural and socio-political influences of the time in which the music was composed. To accomplish this last goal, we have developed a virtual world using OpenSim with images, videos, audio clips and settings that replicate the space and time we are referencing. Students are represented as avatars in the virtual world and can move through the space while conversing with

Fig. 2. Sample of OpenSim activity – Discussion around an instrument called a Gamelan and the cultural and historical influences of and on Gamelan music.

peers. In the virtual world, students engage in a guided discussion as they view and interact with all of these materials.

5 Student Characteristics

Given the diversity of students within introductory music courses, we felt it necessary to explore the potential impact of key student characteristics, including prior music and computer experience and levels of self-regulation.

Recent studies by Demorest et al. [6] and Morrison et al. [11] suggest that prior music training is not a barrier to successful study of unfamiliar music. However, both of these studies explore the enculturation effect – that is, the effect of culture-specific listening and performing on memory, or students' ability to remember unfamiliar music - while Long et al. [10] determine that prior experience is statistically significant in students' ability to perform. These studies do not explore the skill of listening for understanding and communicating cultural context as we are attempting here. Rather, with this project, we seek to determine whether music experience impacts a student's ability to listen to any musical style or genre in addition to examining how they listen and respond to its interpretation.

In contrast to Long et al., Honing [7] asserts that levels of prior experience with music training should make little difference to one's ability to listen and comprehend. To determine if Honing's position on music cognition is a viable basis for the design of on-line listening activities, we conducted premeasures on prior music experience for consideration in data analysis.

Boechler et al. [2], suggest that levels of computer experience can be related to performance levels on a variety of digital tasks and, given that our pedagogical framework is implemented through digital tasks, we also premeasured prior computer experience.

Finally, we premeasured levels of self-regulation because [10] assert that, “The cyclic process of self-regulated learning has been identified as a predictor of achievement in musical skill acquisition and musical performance” (p. 683).

6 Methods

In fall 2014, we ran a pilot project of just the *Articulate Storyline* activities and the *OpenSim* activities. Our first analysis of this data focused on the students’ general perceptions of these activities and investigated if prior traits (self-regulation levels) and experiences (prior computer and music experiences) were related to their overall perceptions of the activities [3]. Students indicated that they enjoyed the activities and that they felt the activities had enhanced their listening and learning experiences.

The current paper describes the analysis of the pilot study log data of the *Articulate Storyline* activities to determine the students’ performance (time on task, the number of page revisits and the percentage of correct responses) and whether any of these performance measures were related to their previously mentioned traits and prior experiences. This is followed by a more in-depth analysis of the students’ perceptions of both Articulate (on-line listening) and OpenSim (virtual discussions) activities.

6.1 Participants and Procedures

Eighty-six post-secondary students took part in the study. Due to incomplete datasets, sixty were included in the final full sample analyses and twenty-nine students completed both the *Articulate* on-line listening activities and the OpenSim virtual discussions.

Before the listening activities commenced, several pre-measures were collected: (1) General demographics (e.g., program, year in program, gender, age), (2) a music experience survey (non-credit music experience), (3) a self-regulation questionnaire (SRQ) [5], (4) a Computer Experience Questionnaire [4].

The Music Experience Questionnaire has nine items relating to previous musical training, including specific questions on learning a musical instrument, singing in a choir, taking dance lessons, studying music theory or history, or reading musical notation. For this study, we also ask whether the student had any previous knowledge of the subject of the class, world music. These were all yes or no questions. The Computer Experience Questionnaire is comprised of three measures: (1) the Software Recognition Test (SRT), which is a measure of general exposure to computer applications and digital materials, (2) the Educational Activities Checklist (EAC), and (3) the Recreational Experience Scale (RES). The SRT requires students to check off the software titles they recognize on a checklist of forty titles, twenty of which are actual titles, twenty of which are foils to control for guessing. The EAC asks students to indicate which education-related computer activities students have carried out (e.g., writing html code, using a formula in a spreadsheet, using a library database). The REC asks students to indicate, on a five point Likert scale, the range of hours per week they spent playing video games or social networking in Elementary, Junior High, High School and University.

The Self-Regulation Questionnaire has 63 items on a 5 point Likert scale such as, "I usually keep track of my progress toward my goals". Self-regulation is the ability to create a plan, then execute and make adjustments to it in order to reach one's goal.

Students were then asked to complete the on-line listening activities that were supplemental to their face-to-face classroom activities. These activities were on the students' own schedule and were self-paced. They completed two sets of four listening activities, one set about meter and one about rhythm, delivered via *Articulate Storyline* at approximately the mid-point in the semester, which is, beginning in Week 7 of a 13-week course.

As our performance outcome measures, we collected log data from the *Articulate Storyline* software as the students completed the listening activities. The performance measures were: (1) the overall time on task, (2) the number of page revisits and, (3) score for correct answers. We considered these three dependent variables as indicators of the students' efficiency in completing the tasks. We also wished to determine if any prior traits or experiences the students brought into these activities were related to their efficiency in completing the tasks. We addressed the following sets of research questions about student performance:

Music Ability

1. Is there a difference in the total time on task as a function of the students' level of prior music experience (High, Low)?
2. Is there a difference in the number of pages revisited as a function of the students' level of prior music experience (High, Low)?
3. Is there a difference in the percentage of correct answers as a function of the students' level of prior music experience (High, Low)?

Computer Experience

4. Is there a difference in the total time on task as a function of the students' level of prior computer experience (High, Low)?
5. Is there a difference in the number of pages revisited as a function of the students' level of prior computer experience (High, Low)?
6. Is there a difference in the percentage of correct answers as a function of the students' level of prior computer experience (High, Low)?

Self-Regulation

7. Is there a difference in the total time on task as a function of the students' level of Self Regulation (High, Low)?
8. Is there a difference in the number of pages revisited as a function of the students' level of Self Regulation (High, Low)?
9. Is there a difference in the percentage of correct answers as a function of the students' level of Self Regulation (High, Low)?

Besides the impact of student characteristics on performance outcomes on the *Articulate* assignments, we were also interested in the students' experiences and perceptions of both the Articulate and the OpenSim sessions and how these might be related to student characteristics. After the course was completed, we administered a survey to the students to get a better sense of their experiences.

We reported a preliminary analysis of these survey results in Boechler, Ingraham, Marin, Dalen and deJong (2015). This was an overall analysis, which we termed *perceived value* of the on-line activity, which used the summed rating across all items in the survey for each student. Using a 5-item Likert scale, the highest positive rating across the entire survey would be 40. For the Articulate data, which represented the full sample, we regressed all the student characteristic variables on the *perceived value* dependent variable. The results indicated that only one of the student variables that were measured at the outset of the study (age) was significantly associated with the students' perceived value of the on-line listening activities [$\beta = .34$, $t(66) = 2.9$, $p < .005$]. Older students had higher positive ratings of the *Articulate* listening activities than younger students.

For the OpenSim data (virtual discussions), we had a smaller sample of 29 students. Given the mean of the summed ratings were 31 (highest possible positive rating being 40); it appears the virtual activities were generally well received by the students. A correlation analysis run on this smaller sample data indicated that none of the student variables that were measured at the outset of the study were significantly associated with the students' perceived value of the virtual discussions.

In the current paper, the survey results were revisited for a more in-depth analysis of specific survey items and their relationships to student perceptions of worth.

7 Results

To detect any differences in performance between different levels of each of the independent variables (prior music experience, prior computer experience and the SRQ), for each dependent variable, (time on task, number of page revisits, number of correct answers) the sample was divided into two groups. Students were categorized as High on each measure if their score was above the mean for that measure. Students were categorized as Low on each measure if their score was below the mean for that measure. An independent samples T-test was then conducted for each combination of independent and dependent variables.

7.1 Music Experience and Performance

Question #1: Is there a difference in the total time on task (minutes) as a function of the students' level of prior music experience (High, Low)? The T-test indicated there was no difference between high and low music experience groups on total task time (High group ($n = 37$, $M = 6.22$, $SD = 3.40$), and the Low group ($n = 22$, $M = 7.97$, $SD = 6.60$), $t(1, 27.77^{*}) = 1.16$, $p = .256$ (* adjusted df for unequal variances). In other words, students with extensive music ability did not complete the listening activities any faster than those with little experience.

Question #2: Is there a difference in the number of pages revisited as a function of the students' level of prior music experience (High, Low)? The T-test showed that the differences in the number of revisited pages between the High group (n = 37, M = 3.59, SD = 12.68), and the Low group (n = 22, M = 3.54, SD = 7.73) was not significant, t (1, 58) = −.016, p = .987.

Question #3: Is there a difference in the score for correct answers as a function of the students' level of prior music experience (High, Low)? No, prior music experience did not help or hinder students in achieving correct answers in the on-line listening activities. (High group (n = 37, M = 154.32, SD = 77.98), and the Low group (n = 22, M = 129.40, SD = 47.55), t (1,58) = −1.35, p = .181.

7.2 Computer Experience and Performance

Question #4: Is there a difference in the total time on task as a function of the students' level of prior computer experience (High, Low)? The T-test on group computer experience yielded no significant differences (High group (n = 35, M = 7.07, SD = 5.30), and the Low group (n = 24, M = 6.58, SD = 4.25), t (1,58) = −.374, p = .710. It did not matter if students were proficient or not with computers. Low computer skills were not related to increased time to complete the listening activities.

Question #5: Is there a difference in the number of pages revisited as a function of the students' level of prior computer experience (High, Low)? Level of computer experience did not produce a difference in the number of pages students revisited, (High group (n = 35, M = 1.97, SD = 6.61), and the Low group (n = 24, M = 5.92, SD = 15.23), t (1, 28.99*) = 1.19, p = .242.

Question #6: Is there a difference in the score for correct answers as a function of the students' level of prior computer experience (High, Low)? Again, computer experience did not seem to play a role in students' abilities to answer the questions correctly (High group (n = 35, M = 139.63, SD = 49.91), and the Low group (n = 24, M = 152.91, SD = 90.35), t (1,58) = .725, p = .471.

7.3 Self-Regulation and Performance

Question #7: Is there a difference in the total time on task as a function of the students' level of Self Regulation (High, Low)? No, no matter the students' level of self-regulation, they did not perform faster or slower. (High group (n = 27, M = 5.96, SD = 3.76), and the Low group (n = 32, M = 7.64, SD = 5.58), t (1,58) = 1.33, p = .190. Self-regulation is the ability to create a plan, then execute and make adjustments to it in order to reach one's goal.

Question #8: Is there a difference in the number of pages revisited as a function of the students' level of Self Regulation (High, Low)? No difference was detected in the number of revisited pages as a result of self-regulation scores, (High group (n = 27, M = 4.85, SD = 15.01), and the Low group (n = 32, M = 2.50, SD = 5.49), t (1, 32.89*) = −.765, p = .450.

Question #9: Is there a difference in the score for correct answers as a function of the students' level of Self Regulation (High, Low)? The T-test was not significant in this case either. (High group (n = 27, M = 149.44, SD = 95.09), and the Low group (n = 32, M = 141.31, SD = 35.41), t (1, 32.07*) = −.420, p = .677.

7.4 Student Characteristics and Perceptions of the On-line Activities

To further elucidate the results reported in [3] we revisited the analysis of the self-regulation levels using a categorical approach. [5] recommended interpreting the total SRQ score as a reflection of self-regulatory functioning. They recommended three ranges for low (1), intermediate (2), and high (3) self-regulation capacities. Given the SRQ values of our sample with valid experiences using the listening activities (n = 63, students that experienced at least one Articulate session), the scores can be classified into these three categories using +/− one standard deviation (SD = 13.787) from the mean (M = 213.95) as cut off points. Perceptions that the on-line listening activities were worthwhile are significantly different between levels of self-regulatory capacity at the $p < .05$ level [$F(2,56) = 6.06$, $p = 0.004$].

Post Hoc comparisons using the Bonferroni test indicate that students with high self-regulation capacities (M = 2.25, SD = 1.28) have a significantly lower perception about the on-line listening activities than students with low (M = 3.55, SD = 1.13) and intermediate (M = 3.69, SD = 1.02) self-regulatory capacity (see Fig. 3).

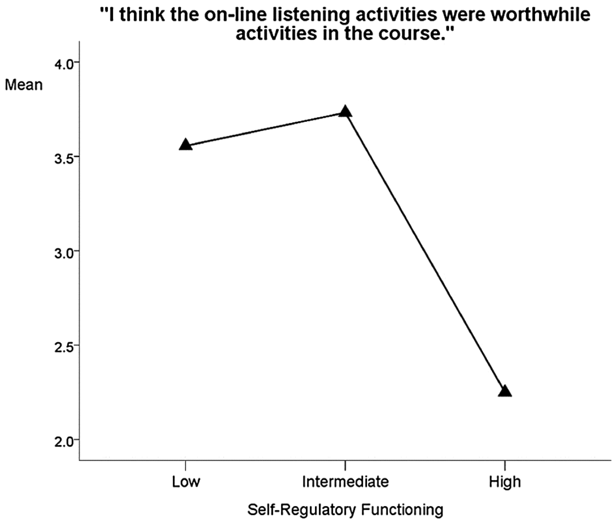

Fig. 3. Mean student's rating of on-line listening activities for different levels of self-regulatory functioning.

In addition, the relationship between self-regulation and computer experience is significant at the $p < .05$ level with this categorical approach [$F(2,60) = 3.67$, $p = 0.031$]. Post Hoc comparisons using the Bonferroni test indicate that students with high self-regulation capacity (M = 32.25, SD = 7.62) have significantly higher computer experience than students with low self-regulatory capacity (M = 21.77, SD = 8.07).

Students with intermediate self-regulatory capacity (M = 26.93, SD = 7.97) do not differ significantly in computer experience from those with low and high self-regulatory capacity (see Fig. 4).

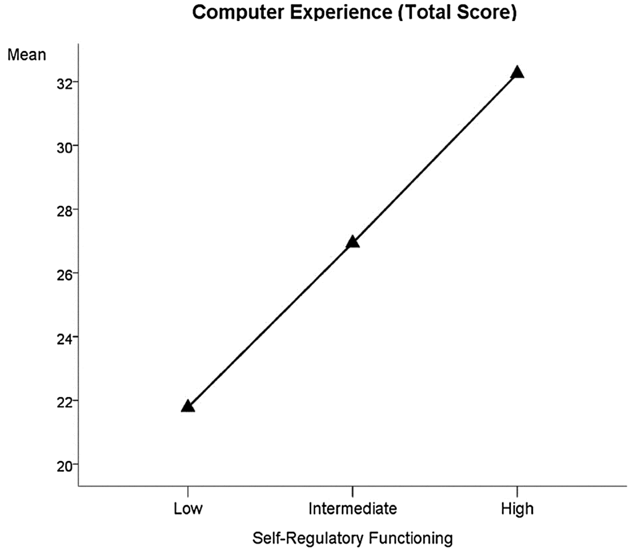

Fig. 4. Mean student's computer experience scores for different levels of self-regulatory functioning.

Subsequent to this new analysis of the on-line listening activities, we were also interested in knowing if the students that experienced both types of on-line activities (n = 29), that is, Articulate on-line listening activities and OpenSim virtual discussions, perceived one of these activities as more worthwhile than the other depending on their level of self-regulation. A visual analysis of mean differences (see Fig. 5) shows that students with high self-regulatory capacity appreciate more positively online discussions (M = 4.0, SD = 0.69) than on-line listening activities (M = 2.5, SD = 0.57). However, since our sample was too small: low (n = 3), intermediate (n = 18), and high (n = 4) self-regulatory capacity, no statistically significant differences in perception of worth are found in the subsample of students (n = 29) that experienced both the on-line listening and virtual discussion activities.

In addition to the scaled survey items, we also asked students to respond to two open–ended questions for each activity: (a) The thing I liked most about the on-line listening activities was… (b) The thing I liked least about the on-line listening activities was…

The self-generated comments were very telling. Students normally liked the on-line listening activities simplicity, easiness of use and ability to help them understand; as one of them shared: "I can listen any time I want to. It is really cool and great for me to practice again and again until I figure out and understand." Reasonably, what students frequently disliked was that "It was too easy!" while suggesting, "Perhaps adding some more difficult ones would improve it."

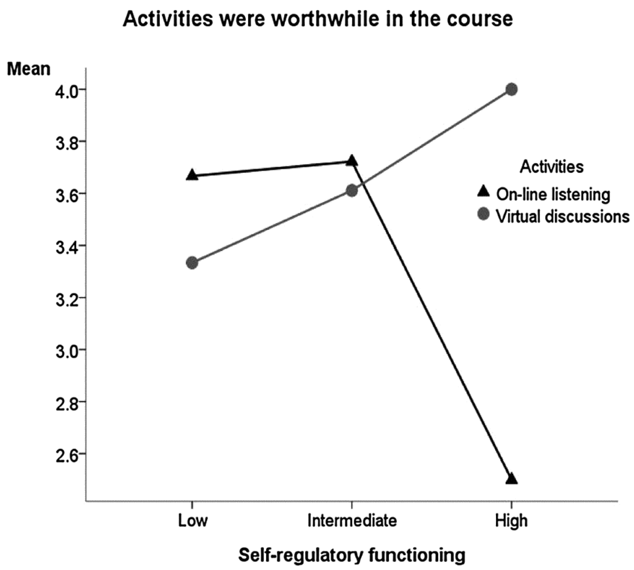

Fig. 5. The difference between categorical levels of self-regulation and perceptions of worth for the subsample (n = 29) that experienced both the on-line listening and the virtual discussion activities.

What students seemed to like the most from their virtual discussions was that there was "a nice instructor," a "leader who helped guide me through the different stations." They also liked "the aspect of some anonymity," the possibility of sharing their thoughts without the embarrassment of the real world because "people do not see each other face to face." Students disliked in general that "it was difficult to install and enter into it" and that sometimes they "had trouble moving around."

8 Discussion

The listening activities described in this paper were a preliminary version of a set of listening activities for music students based on Honing's [7]) concepts of music cognition and Karmiloff-Smith's [8] Representational Redescription Model (RR Model) of knowledge acquisition.

Honing asserts that novice listeners are almost as good as expert listeners in detecting changes in basic musical elements but simply lack the awareness of their implicit knowledge and the music vocabulary to share their perceptions with others.

Our performance results support Honing's assertion, in that prior music experience was not related to students' ability to execute the listening tasks. Students with low music experience were not significantly different in the time they took to complete the task, in the number of page revisits or their scores for correct answers from those students with high music experience. Given that, unlike traditional music courses, we created listening activities that were designed to tap into implicit knowledge and we detected no difference in students with high or low music experience, we suggest that the choice of Honing's cognitive theory as a viable basis for supplemental listening activities is supported.

The Representational Redescription Model provides an implementable framework, through the suggested types of activities, for actually moving learners from Implicit to Explicit and sharable knowledge.

Regarding student perceptions of the on-line activities, an additional categorical analysis indicates a more complicated relationship between self-regulation levels and students' perceptions of the on-line activities than first reported in the preliminary results in [3]. Students with low self-regulation skills find it very hard to make sense or learn actively on their own [1] and novice students learn more deeply from strongly guided learning than from unguided or minimally guided instruction [9]. The advantage of guidance should recede when learners have sufficiently high prior knowledge to provide internal guidance, and more knowledgeable learners should benefit equally from both types of instruction: minimally guided and directed (2006).

If on-line listening activities are considered strongly guided learning, which they are due to their highly structured environment (e.g. True and False options), our data confirms what Kirschner, Sweller, and Clark [9] had stated in regards to novice students. However, it seems that when students are more skilled in regulating themselves, they perceive less value in these highly structured listening activities. Nevertheless, Krischner et al. [9] also stated that the same learner might benefit from stronger and weaker treatments depending on the type of learning and transfer outcome desired; it would be interesting to see if such perceptions change with more advanced musical concepts than the introductory ones used for this pilot study.

Overall, given the impact of this study on student satisfaction and success, we are proposing classroom adoption of this model for listening-focused music courses, adapted according to the content of the course (popular music, classical music, other culture-specific music and so on) and the specific listening outcome required. Listening for musical structure, comparing melodic variation, etc. are also suited to this method.

9 Conclusion

Large introductory post-secondary courses often produce challenges to instructors to provide accessible and meaningful experiences for students. In the case of music courses, listening is a critical activity that is not easily enacted in the large classroom due to noise and other distractions, and to the lack of time for repeated listening and discussion of the listening experience.

The diversity of students within these classes is also a concern as prior traits and experiences may influence their ability derive any knowledge from the degrade classroom listening activities.

The series of technology-enhanced listening and discussion activities that we have designed are theoretically derived and do not disadvantage students with lower skills or less experience than other students. As well, overall, students' perceptions of the activities are highly positive, although there are some differences between students with high, medium and low self-regulation levels. Nonetheless, as a whole, these activities were well received by students.

Therefore, our on-line listening and virtual discussion activities show promise for alleviating some of the limitations of teaching music, particularly close listening skills, in large post-secondary classrooms.

References

1. Azevedo, R.R., Cromley, J.G., Winters, F.I., Moos, D.C., Greene, J.A.: Adaptive human scaffolding facilitates adolescents' self-regulated learning with hypermedia. Instr. Sci. Int. J. Learn. Cogn. **33**(5–6), 381–412 (2005)
2. Boechler, P., Dragon, K., Wasniewski, E.: Digital literacy concepts and definitions: implications for educational assessment and practice. Int. J. Digit. Literacy Digit. Competence **5**(4), 1–18 (2015). doi:10.4018/ijdldc.2014100101. Special Issue on Digital Literacy and Digital Competence: Facts, Problems, Needs and Trends
3. Boechler, P., Ingraham, M., Marin, L.F., Dalen, B., deJong, E.: Making the implicit explicit: music listening, blended delivery and the representational redescription model. Int. J. Cross-Disc. Subj. Educ. (IJCDSE) **6**(1), 2095–2105 (2015)
4. Boechler, P., Leenaars, L., Levner, I.: Recreational vs. educational computer experience: predicting explicit and implicit learning outcomes during a website search. In: McFerrin, K., et al. (eds.) Proceedings of Society for Information Technology and Teacher Education International Conference, pp. 2499–2501. AACE, Chesapeake (2008)
5. Brown, J.M., Miller, W.R., Lawendowski, L.A.: The self-regulation questionnaire. In: VandeCreek, L., Jackson, T.L. (eds.) Innovations in Clinical Practice: A Source Book, vol. 17, pp. 281–289. Professional Resource Press, Sarasota (1999)
6. Demorest, S.M., Morrison, S.J., Jungbluth, D., Beken, M.N.: Lost in translation: an enculturaltion effect in music memory performance. Music Percept. Interdisc. J. **25**(3), 213–223 (2008)
7. Honing, H.: Musical Cognition: The Science of Listening. Transaction Publishers, Rutgers (2009)
8. Karmiloff-Smith, A.: Beyond Modularity: A Developmental Perspective on Cognitive Science. MIT Press, Cambridge (1992)
9. Kirchner, P., Sweller, J., Clark, E.: Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educ. Psychol. **41**(2), 75–86 (2006)
10. Long, M., Hallam, S., Creech, A., Roberston, L.: Do prior experience, gender, or level of study influence music students' perspectives on master classes? Psychol. Music **40**(6), 683–699 (2011)
11. Morrison, S.J., Demorest, S.M., Campbell, P.S., Bartolome, S.J., Roberts, J.C.: Effect of intensive instruction on elementary students' memory for culturally unfamiliar music. J. Res. Music Educ. **60**(4), 363–374 (2013)

Dynamic Adaptive Activity Planning in Education: Implementation and Case Study

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Abstract. Dynamic Adaptive Activity Planning is a technique to create plans in which activities are the best suited for particular users and their context. This paper presents an architecture, called ASHYI, for dynamic adaptive activity planning, and ASHYI-EDU, an application of ASHYI for the educational domain. ASHYI-EDU can automatically create a learning plan for students, according to their specific characteristics, assign remedial activities if students need to reinforce some concepts, and it can update those plans if the student profile or its context change. ASHYI-EDU was implemented as a virtual learning environment (VLE) prototype, and was utilized during two semesters to teach an online course. The results suggest that, although teachers need to invest more time to create learning activities for heterogeneous students, ASHYI-EDU effectively assigns the most alike activities to each student and it also addresses student shortcomings through remedial activities.

1 Introduction

The teaching-learning process comprises several important aspects. One of the most important ones is the planning of activities that a student will perform during a course. An adequate plan of learning activities has the potential to better convey information to students, facilitate their learning, and ensure that students accomplish the learning goals in the curricula [1].

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Traditionally, the teacher defines course activities and the order in which they must be performed by students [1]. This approach, however, does not guarantee that students meet the learning objectives. One of the main causes is student heterogeneity. Each student has different learning styles, skills, competencies, which means that some students will benefit more from some types of activities than from other types [2]. For instance, a student who prefers to obtain information by visual means may benefit more from an activity that conveys information through images or figures. This same student may benefit less from activities that involve lots of reading. Other student may prefer reading rather than viewing images or figures, which means that he/she may benefit more from activities that are not that useful to the other student.

A natural approach to address student heterogeneity is to provide students with a set of custom-tailored activities that are the most adequate to foster their learning process [3]. However, this process, if performed manually, can be very time-consuming, since the teacher must individually analyze each student, find the best activities for that student according to their characteristics, while ensuring that the student still meets the learning goals of the course. In particular, the teacher should define and utilize an adequate mechanism to determine the affinity between students and activities, which is also a time-consuming task.

To address the above problems, this paper proposes ASHYI-EDU, a system that utilizes a dynamic adaptive planning approach to select and organize the best learning activities for each individual student. The approach is adaptive, since different plans are created for each student, based on their specific characteristics, and the context in which they are accessing the system. The approach is dynamic, since it is created based on the changing student characteristics and context and modifies itself as the student and context changes over time. The word "ASHYI" from ASHYI-EDU is a Quechua word that mean to search, to investigate. The combination with "EDU" conveys the idea of searching, investigating to provide education.

Unlike other activity planning approaches [4–12], ASHYI-EDU not only takes learning styles into account, but also other dimensions, such as personality, skills, competencies, learning context. ASHYI-EDU takes into account the dynamic aspects of learning and it is able to modify student plans to adapt to their changing needs and context. Moreover, ASHYI-EDU detects when a student needs to develop specific skills or competencies prior to perform some activities and suggests remedial activities to the student accordingly.

The remainder of this paper describes ASHYI-EDU and its validation in a case study. Section 2 analyzes related work on activity planning in educational environments and highlights the differences with ASHYI-EDU. Section 3 describes ASHYI, the overall architecture for dynamic adaptive planning systems, which is the base for ASHYI-EDU. Section 4 explains ASHYI-EDU in detail, including the prototyping effort. Section 5 describes the validation of ASHYI-EDU through a case study. Section 6 concludes the paper and discusses future work.

2 Related Work

There are several works that involves a degree of planning in e-learning environments. Ott et al. [4] propose a pedagogical planner to assist teachers to create activities and virtual learning objects (VLO). The planner supports aggregation of contents, learning context, target population and learning goals. The system also supports collaboration in the planning creation workflow. An expert outlines the plan, then teachers propose activities, pedagogical strategies, and evaluation metrics. Finally, technology experts propose tools to execute the activities.

The works of [5,6] address the creation of personalized ubiquitous learning, where the student can participate in a course regardless of his/her location and interacting with real objects –museums, gardens, squares, etc–. Learning path creation follows a two-stage heuristic algorithm: First, it determines the relevancy between two learning objects; then it uses a multi-agent-based algorithm to find the best path for each student, according to their characteristics.

Almulla [7] proposes an e-learning recommendation software. The system takes as input student aspects, course lessons, and school and course profiles. That information is processed using data mining techniques to find potential student problems in evaluations and activities. Using that information, the system recommends activities to students to address those problems.

Rytikova et al. [8] show the implementation of a teaching methodology for undergrad courses. The methodology includes a unified curricula repository that organizes the material in a hierarchy. Taking into account individual student competencies and group competencies, different learning elements are assigned, to ensure that the student is satisfied with the assigned material. Each learning element is evaluated through a quiz. There is also a general exam that comprises all the learning elements.

ETeacher [9] is a system to personalize student learning in a virtual environment. ETeacher creates a student profile. Particularly, it utilizes Bayesian networks to analyze determines the student learning style, based on his/her behavior within the virtual course. Based on this profile, ETeacher recommends the student specific activities to each student. The student may accept or reject these recommendations. The system utilizes this feedback to update the student profile.

Hong et al. [10] propose a multi-agent system to assist the student to learn more efficiently, through personalization and adaptation of navigation, presentation, curricula sequence, and taking into account student difficulties. Student profiles are created utilizing a pre-test that is filled by the student the first time he/she uses the system. The system utilizes a genetic algorithm to find the best learning path, based on the test results and the incorrect answers.

Baldoni et al. [11] propose an approach that utilizes a semantic web to create personalized curricula to motivate the student, based on his/her competencies, knowledge, and learning style. The approach comprises five models: domain, curricula, learner, resources, and course. The system generated learning plan focuses on the student learning necessities, course goals, and required/developed competencies.

Table 1. Related work comparison.

	[4]	[5,6]	[7]	[8]	[9]	[10]	[11]	[12]	ASHYI-EDU
Student's data		+	+	+	+			+	+
Context data	+	+							+
Pedagogical goals	+	+		+		+			+
Re-planning		+			+	+			+
Remedial activities			+		+/−				+
Colaboration creating the plan	+		+	+	+				
Learning situation data	+				+	+		+	+

Jamuna et al. [12] propose an e-learning system that utilizes semantic web to facilitate search, retrieval, and interpretation of information, based on student characteristics. The system creates a common ontology to represent the student knowledge. A reasoning mechanism takes into account student preferences, domain knowledge, and learning features to decides what to adapt to the student.

Table 1 summarizes the main features of each related work. The '+' symbol means that the approach fully supports a given feature. The '+/−' symbol means that the approach partially supports the feature. All of the related work supports a subset of all of the relevant features shown in the table. As demonstrated in the remainder of this paper, ASHYI-EDU supports all of the features, except collaboration in creating a plan. The latter is focus of future work.

3 The ASHYI Architecture

An important step in the development of ASHYI-EDU is the definition of its architecture. An essential premise in this research is that the planning problem in ASHYI-EDU is similar to planning problems in other domains. Therefore, one goal of this research is to define a flexible architecture, called ASHYI [13], that could be applied to different domains.

ASHYI provides an abstract definition of the main activities, information, and roles required to adapt a plan and the ways to dynamically change that plan over time. ASHYI is conceived with a sufficient level of abstraction to be applicable to different domains that need dynamic adaptive planning, while being sufficiently specific to provide a sound structure to lead to a more detailed design of an adaptive system.

Figure 1 describes the main elements of the ASHYI architecture. There are three roles: Administrator, who provides the basic information required by a system to perform dynamic adaptive planning; the Planner, who creates an overall plan that would be instantiated into more specific, adapted plans for different people; and, the Executor, who performs the actions in their specially tailored plan and give feedback to the system about their actions.

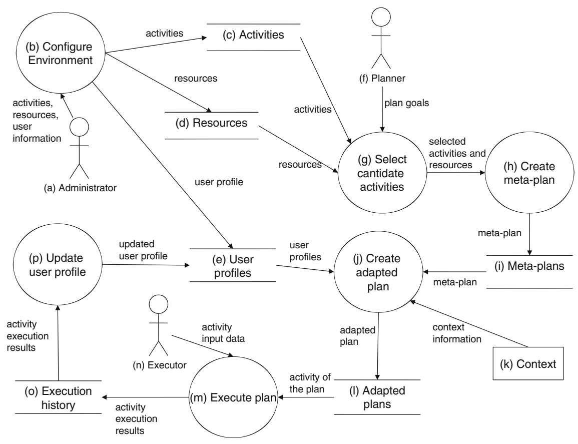

Fig. 1. ASHYI architecture.

The overall planning process in Fig. 1 is as follows. First, the Administrator (a) configures the environment (b), feeding the system with activities, resources, and information about user profiles. This information is stored in three repositories: one for activities (c), one for resources (d) and one for user profiles (e).

Activity information may differ from one domain to another. However, in most cases, activity information stored in (c) should include pre and post-conditions, i.e., assertions that must be true in order to properly execute the activity and assertions that must be true after the successful execution of the activity, respectively. Depending on the domain, pre-conditions could be *strict*, which means that an activity can only begin when all pre-conditions are satisfied or *non-strict*, which means that an activity can begin if some pre-conditions are not satisfied. For the particular case of ASHYI-EDU, pre-conditions are non-strict.

Resources (d) specified by the Administrator are meant to be used by activities. One activity may have one or more assigned activities, where the availability of each resource may depend on context conditions. For example, if an activity requires access to a web site of a university Intranet, and that site access is forbidden outside the university network, that resource will be unavailable when a user tries to perform that activity from outside the university Intranet. In this case, if an alternative resource is available, the activity should be performed with that resource. Otherwise, it should be canceled or delayed until the first resource is available.

User profile information (e) can also specified by the Administrator. This information is relevant for the system to create an adapted plan for each user, based on their specific characteristics. For instance, the administrator may provide through a batch process, all of the student information that has been collected through surveys or tests, which are useful for the system to adapt plans for them.

The above information is the basis to create an adapted plan. In this regard, the Planner (f) is in charge of providing the system with the *goals* of the plan.

Goals are achieved by performing activities and an activity may satisfy one or more goals. Utilizing the goals provided by the Planner, the system must select all of the candidate activities (g), i.e., activities that satisfy all the given goals when combined together.

The candidate activities and their associated resources are the input for the creation (h) of a *meta-plan* (i), which is a general specification of all of the possible adapted plans that the system could generate to different users. Depending on the domain of the problem and the dependency relation between activities, the meta-plan may have a different design. For instance, if pre-conditions are strict, the meta-plan can be built as a graph, where each activity represent an activity and a connection represents the precedence relation between two activities. A graph with those characteristics is utilized in the classic GraphPlan approach [14] to unify all of the possible activity sequences that satisfy chains of pre and post-conditions. Systems with non-strict pre-conditions, such as ASHYI-EDU, utilize a similar overall structure, but the connections between activity nodes are semantically different. More details about ASHYI-EDU meta-plan structure are given in Sect. 4.

The next step is to create the adapted plans (j) that are specially tailored for each user and their context (k). An adapted plan (l) is an *instance* of the meta-plan, which means that multiple adapted plans could be extracted from the same meta-plan. Depending on the application domain and, particularly, on the meta-plan structure, the adapted plans will have specific structures. For instance, in the case of plans with strict pre-conditions, which may be based on the GraphPlan algorithm, adapted plans can be denoted as arbitrary sub-graphs of the meta-plan graph. These plans allow some flexibility in choosing the sequence of activities when two or more activities are not bound by pre or post conditions. Adapted plans in ASHYI-EDU are also sub-graphs of a bigger graph and are generally linear. Flexibility is achieved through remedial activities for students and by constant re-planning (see Sect. 4).

In the last part of the process, the Executor (n) performs all of the activities of an adapted plan (m). The results of each activity are stored in an execution history (o), which can be utilized to update the user profile (p). The process continues until there are no activities left in the adapted plan.

4 ASHYI-EDU

ASHYI-EDU [15] is a component that enhances a virtual learning environment to incorporate dynamic adaptive plannings in learning activities. In other words, ASHYI-EDU is the result of instantiating the ASHYI architecture in the educational domain. ASHYI-EDU assists teachers in the creation of multiple dynamic adaptive plans for different students. Plans are especially tailored to students, based on their competences, skills, personalities, and learning styles, and may incorporate remedial activities to facilitate learning in students who do not have all of the required skills or competencies for a course.

The three roles from ASHYI (Administrator, Planner, and Executor) are mapped into ASHYI-EDU as follows. ASHYI-EDU provides two roles: Teacher and Student, where Teacher assumes both the Administrator and Planner roles from ASHYI, while Student assumes the Executor role.

The responsibilities of each role are the same as in ASHYI, but instantiated to the educational domain. A teacher configures the environment by creating educational activities, learning resources, and characterizing the students who will utilize the system. The teacher also selects a set of candidates activities to specify a meta-plan, which has structure that is specially-tailored for an educational environment. Using this information, ASHYI-EDU creates adapted learning plans for students, who perform the activities and send the results to teachers. The teachers then evaluate those results and send feedback to students. Based on the teachers' evaluations, ASHYI-EDU may create a new plan for a student, based on his/her new profile.

4.1 Course Structure

ASHYI-EDU utilizes a specific course structure, shown in Fig. 2. A course comprises one or more learning units, which are portions of the course focused on specific interrelated topics. Each learning unit may have one or more learning goals that students must accomplish in order to properly learn the contents of the unit. Each goal can be achieved by one activity. However, to provide different options for students, there can be more than one activity aligned with a given goal. A student only needs to fulfill one of them in order to achieve that goal.

A key concept in the course structure of ASHYI-EDU is that each learning unit has their own meta-plan, thus each student is given one adapted plan per learning unit.

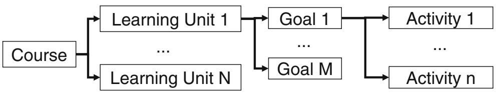

Fig. 2. ASHYI-EDU course structure.

4.2 Configure Virtual Learning Environment

The first stage of the ASHYI-EDU process is to configure the virtual learning environment. First, the teacher must specify all of the learning activities that diverse students may perform and all of the resources that activities may require to be executed. To ensure activity availability to students under various circumstances, it is recommendable that teachers specify more than one resource per activity, so that if a resource becomes unavailable for any reason (e.g. a resource's server becomes inaccessible from certain locations), the student could still perform the activity utilizing substitute resources.

Activities and resources are stored in a repository that is later accessed to select candidate activities and create the meta-plan. The activities in the repository can also be utilized by other teachers when creating their own adapted courses and can also be reused in future versions of the same course.

In parallel, ASHYI-EDU obtains the initial student profiles, which are required to create adapted plans for students. To do this, the first time a student accesses ASHYI-EDU, he/she must complete two tests. The first one is called CHAEA [16] and it is based on the Honey-Alonso Questionnaire for Learning Styles [17]. This test classifies students according to four different styles:

Active: The student tends to be open, enthusiastic and with few prejudices for new experiences. The student is motivated when facing challenges.

Reflexive: The student tends to carefully observe and analyze the situations. They tend to be cautious and distant, and try to take into account all of the alternatives before making a decision.

Theoretical: The student tends to think logically and to integrate his/her observations into complex and logic theories. They seek rationality, objectivity, precision, and exactitude.

Pragmatic: The student tends to put ideas into practice. He/she seeks quickness and efficacy in their actions and decisions. They tend to feel secure when facing projects that they like.

The second test is the Myers-Briggs test [18], which measures personality types. This test measures four different personality trait categories, which may have two different values:

Category 1: Extroverted (talkative, fast paced, communicative) vs Introverted (reserved, slow paced, private).

Category 2: Sensing (concrete, literal, practical) vs Intuitive (imaginative, figurative, holistic).

Category 3: Thinking (logical, objective, reasonable) vs Feeling (empathetic, subjective).

Category 4: Judging (sequential, planner, formal) vs Perceiving (flexible, improvising, spontaneous).

These categories yield 16 different combinations, which in this test means 16 different personalities.

ASHYI-EDU utilizes all of the information from both tests to create the initial student profiles. These profiles not only include learning styles and personality types, but they also include skills and competencies. The former two are static during the execution of a learning unit, while the latter two are updated whenever students perform activities in ASHYI-EDU and receive feedback from teachers. More details about the student profile are shown in Sect. 4.6.

4.3 Activity and Resources Selection Using PUMAS-LITE

After the activity and resource repository has sufficient activities, the teacher can select the most relevant ones to provide adapted learning plans to students. Recall that students get assigned one adapted plan per learning unit. Therefore, teachers must select candidate activities and resources in a learning unit basis.

To assist teachers in the activity selection process, ASHYI-EDU provides a module called PUMAS-LITE. PUMAS-LITE is a lightweight version of PUMAS

[19], a multi-agent system to seek resources in a distributed environment, while taking into account specific characteristics of users and context. In particular, PUMAS-LITE is able to select the best activities, according to the learning unit goals.

Figure 3 describes the PUMAS-LITE architecture, which comprises five agents. The Context Agent is in charge of detecting changes in the user's context and react accordingly. There is one Context Agent per user in the system. The Representative Agent manages student profiles in the system and there is one of them per student. The Representative Agent delegates queries into the Intermediary Agent. The latter collects queries from different Representative agents and pass them into the Router Agent. The Router Agent seeks the information sources that are able to answer the query received from the Intermediary Agent. After the information source is located, this agent sends the query to the corresponding Information Source Agent, who is in charge of answering the query.

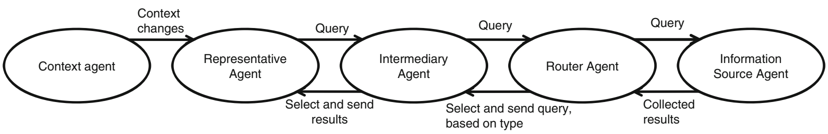

Fig. 3. Overview of PUMAS-LITE.

4.4 Meta-planning

After the teacher selects a set of candidate activities for a learning unit, ASHYI-EDU creates a *meta-plan*, a structure that serves as the foundation to every possible adapted plan in that learning unit.

Figure 4 is an example of a meta-plan. In ASHYI-EDU, a meta-plan is a directed multipartite graph, in which nodes represent activities that students can perform in a learning unit and direct connections represent the precedence relations between activities.

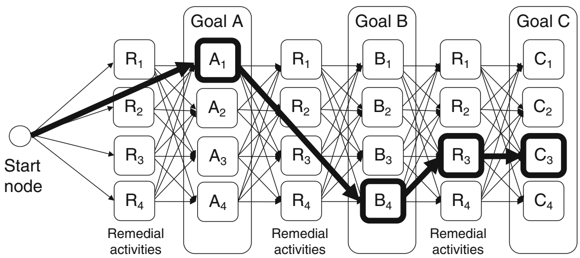

Fig. 4. Example meta-plan in ASHYI-EDU.

To be more precise, nodes in the meta-plan represent pairs of activities and resources that are sufficient to accomplish a given learning goal. This means that there could be multiple resources that could be utilized by the same activity in order to satisfy a goal. For instance, an activity associated to learn about a certain topic could be achieved either by reading a book chapter or an electronic paper. In both cases the activity is the same (reading), but the resources are different. In practice, this means that the meta-plan can contain several nodes corresponding to the same activity, but paired with different resources.

Columns in the graph correspond to partitions that group nodes: goal partitions and remedial partitions. Goal partitions group activities that are aligned with specific goals of the learning unit. Remedial partitions group remedial activities, i.e., activities that are not directly aligned to learning unit goals, but they aim to develop specific skills or competences in students that may be required by goal-aligned activities. Remedial partitions always contain the same set of activities.

In a learning unit, goals are ordered in a sequence given by the teacher when creating the course. The corresponding goal partitions in the meta plan follow the same order. Remedial activities can be executed in between goal-aligned activities, thus remedial partitions are placed in between goal partitions.

The nodes in each partition are fully connected to the nodes in the following two partitions, which are always a remedial and a goal partition. For space reasons, the Fig. 4 only shows the connections to the immediately adjacent partitions.

4.5 Adapted Plans

Adapted plans are extracted from a meta-plan and are the selection of the most adequate activities for specific students, based on their characteristics.

In practice, an adapted plan is the shortest path from the start node in the meta-plan graph to one of the nodes in the rightmost partition. Figure 4 depicts an adapted plan as a path in the graph with thicker edges. The path in the meta-plan will vary according to student characteristics. In particular, if a student lacks certain skills or competences, ASHYI-EDU may include remedial activities in the adapted plan. For instance, the adapted plan in Fig. 4 ($A_1 \rightarrow B_4 \rightarrow R_3 \rightarrow C_3$) includes remedial activity R_3 within the sequence.

4.6 Matching Students to Activities

Although the meta-plan general graph structure is common to all adapted plans, the edge weights are calculated differently for each student. The weight of each edge is based on a *distance function* that represents the affinity between students and activities. The lower the distance, the more affine is a student with the activity to which the edge is pointing.

To better explain the distance function it is important to understand the student and activity profiles, since the distance is measured between these two elements.

For the purposes of the distance function, both student and activity profiles are represented as a vector depicted in Fig. 5. There are 4 components to represent learning styles, 16 components to represent each personality type, 19 components to represent skills, and 16 competencies. Learning styles and personality types are always the same for each course, while skills and competencies vary from one course to another.

Learning Styles 1 ... 4	Personality Types 1 ... 16	Skills 1 ... 19	Competencies 1 ... 16

Fig. 5. Student and activity vectors.

Although the vector structure is the same for both students and activities, they are interpreted differently. For students, the vector is interpreted as follows:

Learning Style components are values between 0 and 1 that indicate the degree each student prefers each learning style. The closer a component value to 1, the most preference the student has for the corresponding learning style. A student may have more than one component with values greater than 0.

Personality Type components are values that can be either 1 or 0 and indicate whether the student has a given personality type or not. Only one component can have a value different than 0, which is consistent with the Myers-Briggs test (see Sect. 4.2).

Skill components are values can be either 0 and 1. They represent whether a student has developed a particular skill or not at a given time during the execution of an adapted plan. A value of 0 means the student has not developed the corresponding skill, while a value of 1 means that the student has developed the skill. Since a student may have developed multiple skills, more than one skill component can have a value different than 0.

Competence components are similar to skills. They represent whether a student developed certain competencies or not. Competency values can either be 0 (undeveloped competency) or 1 (developed competency). There can also be multiple competency values different than 0.

In contrast, activity vectors are interpreted as a non-strict set of preconditions that the student should fulfill to properly perform the activity:

Learning Style components are values between 0 and 1 that indicate which learning styles are better suited to perform the activity. The closer a component value to 1, the most adequate is the activity for students who prefer the corresponding learning style. An activity may have more than one component with values greater than 0.

Personality Type components are values that can be either 1 or 0 and indicate the personality types who can benefit more from performing the activity. Multiple components can have a value different than 0, which means that an activity can be adequate for various personality types.

Skill and Competency components are values can be either 0 or 1. They indicate that it is highly recommended that the student develops that skill/competency before executing the activity. Therefore, more than one component may have a value greater than zero.

Equation (1) is the distance function in ASHYI-EDU. This function takes as input a student vector S and an activity vector A and yields a scalar that represents the affinity between the corresponding student and activity.

$$d(S,A) = w_l d_l(S,A) + w_p d_p(S,A) + w_a d_a(S,A) + w_c d_c(S,A) \quad (1)$$

Some components in the activity and student vectors have discrete values of 0 or 1 (personality types, skill, competences), while other components have continuous values between 0 and 1 (personality types). Therefore, the distance function combines four different functions to calculate to overall distance.

Function d_l is the euclidean distance between learning style components of S and A. Function d_p is the euclidean distance between personality types of S and A. Functions d_a and d_c are the Jaccard [20] distance between skill and competency components of both vectors, respectively.

The weights w_l, w_p, w_a, and w_c are applied to d_l, d_p, d_a, and d_c, respectively. Currently, all of them have the same value (0.25). Ongoing work is to determine which functions should have more weight than others.

4.7 Adapted Plan Execution

After the adapted plan is created, the student can execute it. To begin, the student can access his/her adapted plan through a page that list the sequence of planned activities. Figure 6 is an example of an adapted plan, as shown by ASHYI-EDU to the student.

Using that interface, the student sequentially performs each activity in the adapted plan. After finished, he/she submits the results to the teacher, utilizing the section “Upload file” of the form in Fig. 7. This figure is a modified screenshot from the application in which texts have been translated to English and the image has been edited to fit on the document.

The teacher receives the student results of the activity through the same form and evaluates them. Part of the evaluation given by the teacher is to determine whether the student learned the skills and competencies that the activity should develop. To provide this information to ASHYI-EDU, the teacher utilizes the section “Skills and competences achieved by the student” of the form in Fig. 7.

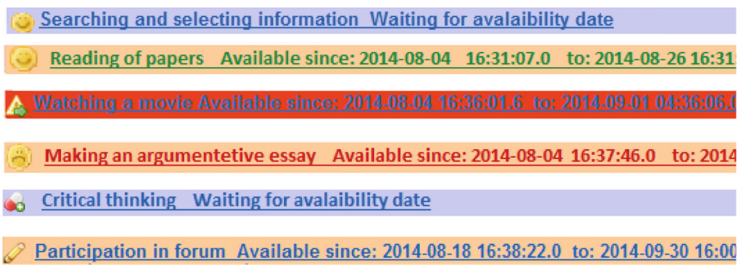

Fig. 6. Example adapted plan in ASHYI-EDU.

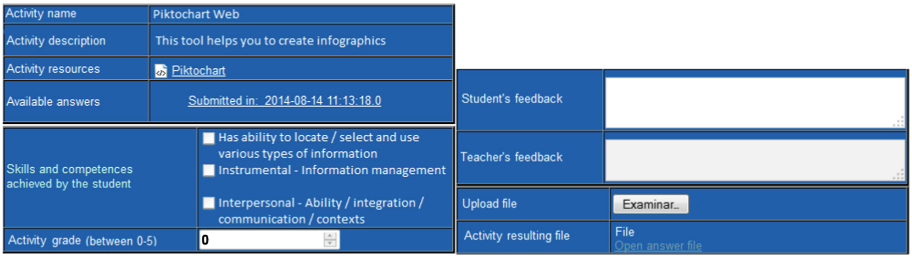

Fig. 7. Adapted plan execution form.

This information is sent to the student as feedback and is also utilized by ASHYI-EDU to determine whether the adapted plan needs to change or not. If so, ASHYI-EDU creates a new plan for the student taking into account changes in the student profile (and also changes in context). The student keeps executing activities until there are no activities left in the current plan.

4.8 Context and User Changes and Re-planning

Under certain circumstances, the execution of activities may not occur according to plan. For instance, a student may not learn all of the expected skills an competencies taught by an activity. In other cases, activity resources may not be available due to context-specific situations. For instance, some activities may need access to electronic bibliographical resources that are only available when the student connects from within the university network. If the students tries to execute the activity from another network, he/she may not be able to access that resource and may not be able to properly execute the activity.

Adapted plans created by ASHYI-EDU are based on the assumption that the student will perform adequately in all of the assigned activities and no unforeseen circumstances will occur during the plan execution. Therefore, when situations like the above ones occur, the adapted plan of the student might need changes, to ensure that the student effectively follows the best learning path for his/her current scenario.

ASHYI-EDU is able to automatically detect the main situations indicated above and create a new plan that is more adequate to the new conditions of the student and the context.

In its current version, ASHYI-EDU is able to perform re-planning under the following circumstances:

1. The student does not properly develop the expected skills and competencies taught by an activity. To address this case, ASHYI-EDU updates the student profile accordingly and creates a new plan that is more affine to the student's current characteristics. In some cases, the new plan may include remedial activities to assist the student to learn lacking skills or competencies.
2. Due to changes in context, the student is not able to access a resource required by the activity he/she is performing. To address this case, ASHYI-EDU

removes from the meta-plan all of the nodes that contain inaccessible resources and finds a new adapted plan under these constraints. Recall that each node in the meta-plan corresponds to pairs of activities and resources, thus removing nodes with the inaccessible resources does not necessarily remove all the nodes with the same activity.

3. The teacher cancels a given activity or decides to make it unavailable to students. To address this case, ASHYI-EDU removes all of the corresponding nodes from the meta-plan (the nodes containing the cancelled/unavailable activity) and executes the planning process again over the reduced meta-plan.

To detect the above circumstances, ASHYI-EDU utilizes several strategies. To detect whether a student learned the expected skills and competencies, activities have a *postcondition vector*, which includes the 19 skills and 16 competencies from the vector of Fig. 5. This vector is not utilized by the distance function. Instead, it represents the skills and competencies that the student should develop after successfully performing an activity. Whenever the teacher's feedback does not correspond to the postcondition vector, a re-planning is triggered.

Resource inaccessibility is currently detected by obtaining the student's IP address. If the IP is not among the ones that should be allowed to access the resource, a new plan is created to reflect these changes.

Activity cancellation/unavailability is addressed by providing the teacher direct control over the activities in the meta-plan. The teacher can explicitly mark activities as (un)available to students. ASHYI-EDU will only consider available activities to create adapted plans.

5 Case Study

To validate ASHYI-EDU, we developed a case study in a university course for students of the career of Primary School Teacher. The course is called "Learning to Learn in the Web". This course utilizes blended learning and its goal is to give the students tools to learn in the web.

This course is being taught each semester to different groups of students. The case study spans through three semesters. The first semester (Spring 2014) included an "offline" course that did not use ASHYI-EDU and relied only on manual procedures to create adapted plans and interact with students. On the second semester (Fall 2014), the course was taught online, utilizing ASHYI-EDU to manage the entire course planning and student-teacher interaction. The third semester (Spring 2015) also utilized ASHYI-EDU and included software improvements, such as detailed reports for the teacher about students' progress.

5.1 Offline Course

This course is called *offline* because it was taught without the help of a virtual learning environment. The teachers evaluated students and created adapted plans manually.

The course had 32 students, from which only 8 filled the tests to define their profiles. They were from different careers: Middle School Spanish Teaching Licentiate, Accounting, Psicology, and Information Sciences.

Table 2 shows the characteristics of the students who took that course. Columns 2 to 5 correspond to learning styles scores, where the maximum value is 20. The last 8 columns correspond to personality traits, where E means Extroverted, I means introverted, N means Intuitive, S means Sensing, T means Thinking, F means Feeling, J means Judging, and P means Perceiving.

Table 2. Student characteristics in the offline course.

Student	Active	Pragmatic	Reflexive	Theoretical	Personality							
					E	I	N	S	T	F	J	P
E1	7	8	12	8	X		X		X		X	
E2	10	17	17	18	X		X			X	X	
E3	17	16	18	17	X			X		X	X	
E4	7	18	19	16	X		X			X	X	
E5	12	12	10	6	X		X			X	X	
E6	7	14	18	14	X		X			X	X	
E7	14	15	16	17	X		X		X		X	
E8	10	13	13	13	X		X		X		X	

As shown in that table, there are students who have different learning styles and personality traits. Most students have high preferences for Reflexive and Theoretical styles, while fewer ones prefer Pragmatic and Active styles.

Table 3 summarizes the results of the execution of the first learning unit. Grades are in a scale of 0 to 5. The teachers determined that the low performance of some of them was due to lack of reading comprehension and writing skills. Therefore, they proposed a set of remedial activities to address these issues.

5.2 Online Courses

To teach the online courses, we utilized a prototype of ASHYI-EDU that is based on Sakai [21], a Java-based virtual learning environment software. The implementation of ASHYI-EDU relies on a modified version of Sakai's Lesson Builder component that includes dynamic activity planning to build learning units and its lessons and a simple interaction facility for students and teachers. The online course structure comprises three learning units. The first learning unit has 4 goals, the second has 3 and the third one has 4. Each activity in the meta-plan is either a course activity aimed to satisfy one of those objectives or a remedial activity.

The development of the online course focuses on automatically performing several tasks that were slow or cumbersome in the offline course: (i) providing

Table 3. Results of the first learning unit.

Student	Grade	Grade Analysis
E1	3	Did not execute all activities
E2	3.2	Incomplete work. Didn't do what was asked for
E3	1	Incomplete work. Didn't do what was asked for. Writing errors
E4	5	
E5	5	
E6	4.6	Does not clearly express ideas
E7	4.4	Does not clearly express ideas
E8	2.5	Incomplete work. Didn't do what was asked for. Does not clearly express ideas

adapted plans according to the necessities of each student, (ii) automatically re-planning according to context changes, and (iii) register the interaction between users and the system.

The ASHYI-EDU prototype provides several features to facilitate the creation of dynamic adaptive plans and monitor their execution. Recall Fig. 4 that shows the meta-plan of a learning unit that is built by the teacher. The teacher can create, modify or remove activities from the meta-plan and the system will automatically organize them according to learning goals and activity type (course or remedial).

The online version of the course was taught the following two semesters after the offline course (Fall 2014 and Spring 2015). Most of the online course structure is based on the offline course. To better adapt learning plans to students, the online version adds more activities, so that each learning goal can have several alternative activities to achieve it. The study on the Fall 2014 semester involved all of the course 29 participants: 23 women and 6 men. The students were from different backgrounds: Education, Accounting, Information Sciences, Psychology, Software Engineering, Business Administration, and Microbiology. The study on the Spring 2015 semester involved 23 students, 19 women and 4 men. Their backgrounds were Education, Accounting, Odontology, Microbiology, Nutrition, Business Administration, and Systems Engineering.

5.3 Results

During the online courses, we proved that ASHYI-EDU is able to provide different plans for different students, according to their specific characteristics. To illustrate this idea, Figs. 8 and 9 are the adapted plans for two students of the online courses, which will be anonymized as A and B, respectively. The texts from the original figures have been translated from Spanish to English.

For simplicity, the chosen examples are not radically dissimilar but, in practice, two students may have very different plans. In this example they have two important differences:

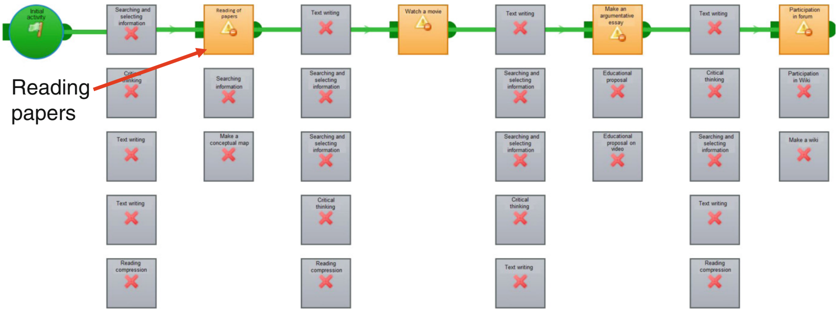

Fig. 8. Adapted plan for student A.

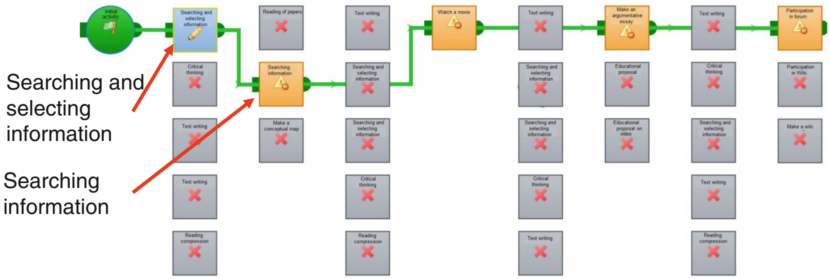

Fig. 9. Adapted plan for student B.

Remedial Activities: ASHYI-EDU did not plan remedial activities for the Student A, while it planned a remedial activity, called "Searching and Selecting Information" (shown in blue) for Student B. This activity aims to develop analysis and synthesis abilities in the student. ASHYI-EDU assigned the remedial activity, because the student B lacked these abilities for the course activity "Searching information".

Course Activities: The first learning goal of the course (third column in both graphs) is to analyze, reflect and understand the information search process. To achieve this goal, ASHYI-EDU assigned Student A a paper reading activity to develop reading comprehension abilities, while the Student B had to perform information search to learn critical thinking and analysis and synthesis abilities. These activities were assigned according to the student learning styles and personalities:

Student A: Learning Style: Active - level: 15, Pragmatic - level: 19, Reflexive - level: 19, Theoretical- level: 19; Personality: ENFJ; Skills: understanding, observation, generates own answers from their knowledge and experience, shows interest and initiative to continue learning, agility and adaptability, empathy, and global vision, interpersonal relationships and managing emotions and feelings.

Student B: Learning Style: Active - level: 6, Pragmatic - level: 7, Reflexive - level: 15, Theoretical- level: 12; Personality: INFJ; Skills: understanding, relate their reality with the environment, interpret and analyze information, observation, generates own answers from their knowledge and experience.

During the Spring 2015 semester, we enhanced the prototype with a report module that can show the evolution of students and their results at the end of the course. Figure 10 includes two example reports for a specific learning unit at a specific time during the Fall semester. They are screenshots of the prototype, which we modified to remove real student names and to translate labels from Spanish to English. The upper half of Fig. 10 shows the state of the plans students. From the 12 students, 3 had required re-planning due to changes in their own profiles, 0 required re-planning due to changes in the context, 0 are just beginning the course and 9 are still following the original plan. The lower half of Fig. 10 indicates the state of all 73 skills and competencies. There are 36 new skills and competencies students acquired during the execution of the learning unit, 14 are currently being acquired, 9 have not yet been obtained, 4 have been removed due to re-planning, and 10 have already been obtained by students.

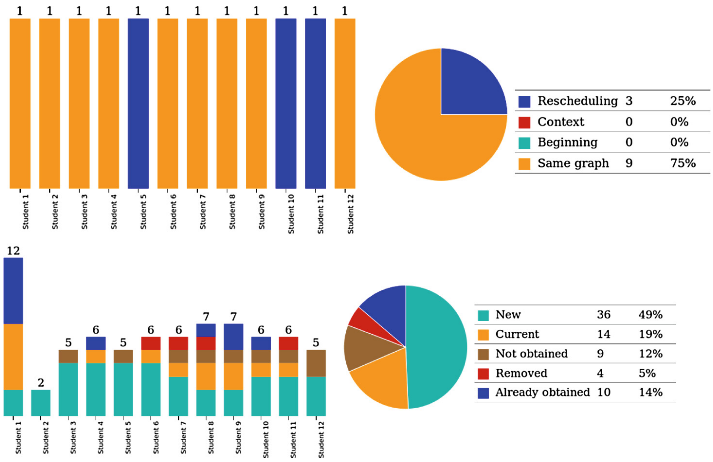

Fig. 10. Replanning and learning reports.

In addition, students were interviewed to determine their satisfaction with the online course. The overall responses were positive. The students expressed that the course helped them to understand the way they approach to learning in the course, which learning styles are the most important in their learning process, and the most adequate activities for them. The students felt more identified and comfortable with the activities that they performed. Similarly, they felt that the inclusion of remedial activities helped them to improve their performance.

From the point of view of the teachers, one important change is the amount of effort to create the course content. While a traditional course may need only one type of activity per learning goal, ASHYI-EDU, requires several activities per learning goal. Another important change is that teachers require to characterize each activity to determine how alike are them to specific types of students. The above requires a high initial effort to create the course. However, the repository provided by ASHYI-EDU has the potential of reducing this effort by facilitating reuse of existing material.

6 Conclusions and Future Work

This paper presented ASHYI, an approach for dynamic adaptive activity planning, together with ASHYI-EDU, an instantiation of ASHYI for the educational domain. ASHYI captures the essential processes and information flow to provide adapted plans, regardless of the application domain. ASHYI-EDU characterizes students, based on personality and learning style tests. ASHYI-EDU creates adapted plans that take into account those characteristics and adapts to changes in context and is able to dynamically re-plan under different constraints.

Overall, the proposed system provides fine-grained adaptive plans to different students, based on more detailed profiles than existing approaches. Another advantage is the ability to re-plan based on context and user information, while providing the most adequate plan during the learning process. Moreover, the automatic assignment of remedial activities further improves the learning process, since it supports the development of required abilities and competences.

This paper also presented a Virtual Learning Environment prototype that implements ASHYI-EDU, and its application in two semesters of a course. The students' feedback from those semesters suggests two important insights. First, that ASHYI-EDU assigns adequate activities to each student, based on their specific abilities, competencies, personality traits, and learning styles. Second, the assignment of remedial activities effectively supports learning needs of the students.

This research also concluded that the matching process between students and activities matching process is as good as the information in the student and activity profiles. Further validation of the proposed approach requires: to ensure that the tests utilized to build the student profile are the most effective ones to capture the student characteristics, and that the activity profiles are effectively the most adequate for certain types of students. In addition, it is also important to test ASHYI-EDU with courses on different topics, to ensure the approach also works for other knowledge areas.

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References

1. Brijaldo, M.I.: Los estilos de aprendizajes como fundamento para la personalización y adaptación de procesos de evaluación en estudiantes universitarios: Desarrollo de una plataforma de análisis multicriterio, Buenos Aires, Argentina (2015)
2. Carrillo-Ramos, A., Rios, M.Y.U., Rodríguez, M.I.B., León, L.F.B., Modera, M.L.S., Mejía, N.A., Pavlich-Mariscal, J.A., Quimbaya, A.P., Vargas, J.E.C.: ASHYI: Plataforma basada en agentes para la planificación dinámica, inteligente y adaptativa de actividades aplicada a la educación personalizada. Editorial Javeriana (2015)
3. Sangineto, E., Capuano, N., Gaeta, M., Micarelli, A.: Adaptive course generation through learning styles representation. Univ. Access Inf. Soc. **7**, 1–23 (2008)

4. Ott, M., Dagnino, F.M., Pozzi, F.: Intangible cultural heritage: towards collaborative planning of educational interventions. Comput. Hum. Behav. **51**, 1314–1319 (2014)
5. Hwang, G.J., Kuo, F.R., Yin, P.Y., Chuang, K.H.: A heuristic algorithm for planning personalized learning paths for context-aware ubiquitous learning. Comput. Educ. **54**, 404–415 (2010)
6. Yin, P.Y., Chuang, K.H., Hwang, G.J.: Developing a context-aware ubiquitous learning system based on a hyper-heuristic approach by taking real-world constraints into account. Univ. Access Inf. Soc., 1–14 (2014). doi:10.1007/s10209-014-0390-z
7. Almulla, M.: School e-Guide: a personalized recommender system for e-learning environments. In: Proceedings of the First Kuwait Conference on e-Services and e-Systems, eConf 2009, pp. 2:1–2:5. ACM, New York (2009)
8. Rytikova, I., Boicu, M.: A methodology for personalized competency-based learning in undergraduate courses. In: Proceedings of the 15th Annual Conference on Information Technology Education, SIGITE 2014, pp. 81–86. ACM, New York (2014)
9. Schiaffino, S., Garcia, P., Amandi, A.: eTeacher: providing personalized assistance to e-learning students. Comput. Educ. **51**, 1744–1754 (2008)
10. Hong, C.M., Chen, C.M., Chang, M.H., Chen, S.C.: Intelligent web-based tutoring system with personalized learning path guidance. In: 2007 Seventh IEEE International Conference on Advanced Learning Technologies, ICALT 2007, pp. 512–516 (2007)
11. Baldoni, M., Baroglio, C., Brunkhorst, I., Henze, N., Marengo, E., Patti, V.: Constraint modeling for curriculum planning and validation. Interact. Learn. Environ. **19**, 81–123 (2011)
12. Jamuna, R., Ashok, M., Palanivel, K.: Adaptive content for personalized E-learning using web service and semantic web. In: 2009 International Conference on Intelligent Agent Multi-agent Systems, IAMA 2009, pp. 1–4 (2009)
13. Pavlich-Mariscal, J.A., Uribe, Y., Barrera, L., Pomares, A., Mejía, N., Carrillo-Ramos, A., Fabregat, R., Baldiris, S.M.: An architecture for dynamic and adaptive user activity planning systems, Lisbon, Portugal (2015)
14. Blum, A.L., Furst, M.L.: Fast planning through planning graph analysis. Artif. Intell. **90**, 281–300 (1997)
15. Pavlich-Mariscal, J.A., Uribe, Y., Barrera, L., Mejía, N., Carrillo-Ramos, A., Pomares, A., Brijaldo, M., Sabogal, M., Vicari, R.M., Martin, H.: ASHYI-EDU: applying dynamic adaptive planning in a virtual learning environment, Lisbon, Portugal (2015)
16. Alonso, C., Gallego, D., Garcia, J.: CHAEA - Estilos de aprendizaje (2009)
17. Honey, P., Mumford, A.: The Manual of Learning Styles, 3rev edition edn. Peter Honey Publications, Maidenhead (1992)
18. Myers, I.B., McCaulley, M.H., Quenk, N.L., Hammer, A.L.: MBTI Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator, 3rd edn. Consulting Psychologists Press, Palo Alto (1998)
19. Carrillo-Ramos, A., Villanova-Oliver, M., Gensel, J., Martin, H.: Knowledge management for adapted information retrieval in ubiquitous environments. In: Filipe, J., Cordeiro, J., Pedrosa, V. (eds.) Web Information Systems and Technologies. LNBIP, vol. 1, pp. 84–96. Springer, Heidelberg (2007)
20. Candillier, L., Fessant, F., Meyer, F.: Designing specific weighted similarity measures to improve collaborative filtering systems. In: Perner, P. (ed.) ICDM 2008. LNCS (LNAI), vol. 5077, pp. 242–255. Springer, Heidelberg (2008)
21. Apereo-Foundation: Sakai (2014)

A Meta-Modeling Approach for Capturing Recurrent Uses of Moodle Tools into Pedagogical Activities

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Abstract. Teacher's expertise on using Learning Management Systems (LMS) is tightly coupled to how they design their online courses. The GraphiT project aims to help teachers in specifying of pedagogically sound learning scenarios that can be technically executable for automatically setting-up the related LMS course. We intend to provide teachers with LMS-specific instructional design languages and editors. To achieve this goal, we have to raise the LMS semantics in order to enrich the pedagogical expressiveness of the produced models. We propose a specific LMS-centered approach for abstracting the low-level and turning these semantics into higher-level pedagogical building blocks. We present and illustrate our propositions focused on Moodle. In this paper, we focus on the first abstraction level: identifying pedagogical activities according to recurrent uses of Moodle activities.

Keywords: Instructional design · Learning management system · Visual instructional design language · Modeling and Meta-modeling

1 Introduction

Learning Management Systems (LMS) are presently widely spread in academic institutions. They are not only used for distant courses but also during or in complement to face-to-face learning sessions [1]. We conducted a study with 203 teachers about their LMS uses. Main feedbacks point out the 'heavy' form-oriented of LMSs human-interfaces and their tools/services-oriented course design. These obstacles lead to reduce the LMSs uses. In order to set up complex learning activities upon an existing LMS, teachers have to develop high-level skills and practices. Some of these skills can be acquired through specific teacher education programs although they are often focusing on LMSs features and technical aspects instead of dealing with specific pedagogical techniques. Because of the multiple educational theories and approaches [2], as well as the lack of tools and processes dedicated to existing LMSs, teachers develop *ad hoc* and individual learning design techniques.

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In such a situation, it could be considered relevant to help teachers in focusing on pedagogical aspects when designing and setting-up a learning situation for a specific LMS they have at their disposal. In opposite to the current feature-oriented programs for improving teachers' knowledge and abilities about what the LMS can do, we propose to follow an instructional design approach encouraging individual and collective understandings about the pedagogical uses of the targeted LMS: what can be pedagogically done and how realize it from the current LMS features.

To this goal we propose an LMS-centered design approach in opposition to the usual platform-independent approaches [3,4]. The main problem of these approaches relies on the gap between rich/poor pedagogical expressiveness of, on one hand, LMS-independant learning scenarios and, on the other hand, resulting course-spaces after translating/setting-up the scenario into an existent LMS. In the GraphiT project (Graphical Visual Instructional Design Languages for Teachers) we aim to tackle this issue. The project main objective is to investigate Model Driven Engineering (MDE) techniques for supporting the specification of LMS-centered graphical instructional design languages and the development of dedicated editors. This paper deals with one central challenge: raising the pedagogical expressiveness of LMSs learning design semantics by using MDE techniques.

We detail in Sect. 2 our research context, including the presentation of the GraphiT project. We also position our current results in regard to other approaches. Section 3 is dedicated to a survey and series of interviews we conducted with designers in order to collect needs and requirements for the Moodle LMS. A global presentation of our abstraction proposition is drawn up into Sect. 4. Section 5 focuses on the proposition of a specific method to identify the pedagogical activities and their bindings to LMS tools. We also use the specific weaving language we developed to formally capture these bindings. Section 6 illustrates our propositions by a concrete learning scenario.

2 TEL and MDE Research Context

2.1 Instructional Design and LMS Compatibility

LMSs developments generally follow an implicit educative theory rationale, or some specific pedagogical approaches. For example, the Moodle LMS claims a socio-constructivist pedagogy philosophy [5]. Widespread LMSs generally follow such an orientation because of the various production and communication tools they provide. LMSs are the activity-centered evolution (rather in a feature-centered meaning) of former content-centered TEL-systems. Indeed, current LMSs provide designers with some numerous functionalities that can be used to realise various learning activities. LMLSs are not restricted to provide resources access to students.

Nevertheless, activity-centered standards like the *de facto* IMS-LD [6] fail to integrate existing LMSs. Experiments on extending Moodle to import IMS-LD learning scenarios proved that adapting existing LMSs requires some complex and heavy re-engineerings (in particular integrating a dedicated runtime-engine) in order to overcome the limitations of the platform features and semantics

[7]. Educational Modeling Languages (EML) [8] fail to provide a support for operationalizing EML-conformed learning scenarios into existing LMSs. Until now, widely spread LMSs like Moodle still do not propose an IMS-LD compliance.

Interestingly though, Moodle proposes its own format for importing questions into quizzes. Our idea is to generalize it to the whole instructional design aspects. Similarly to the SCORM [10] compliance about Learning Objects, the rationale of the GraphiT project is based on the idea that LMSs should make explicit their learning design format in order to facilitate the import/export of compliant learning scenarios, and, in addition, to foster the development of LMS-dedicated instructional design editors.

2.2 Some State-of-the-Art Learning Design Tools and Languages

The project main goal is to study the possibilities and limitations about the pedagogical expressiveness of operationalizable languages. According to the classification of Educational Modeling Languages proposed by [11], our objectives map to **formal** languages, i.e. with closed set of concepts and rules for composing the designs, with an **implementation** level of elaboration, i.e. the highest level of detail achieving maximum precision, with a **visual** notation system.

The *Glue! architecture*, including the *Glue!PS* editor [3], and the CADMOS editor [4] are two recent research works sharing our learning design criteria about pedagogical sound and executable learning design editors. They both propose an LMS-independent solution offering an LMS deployment feature towards the most widespread and used platform: Moodle [12]. They both achieve the deployment by generating a Moodle course backup with all the information and mapping their own data model concepts to Moodle data model concepts; this backup is then imported and deployed within a Moodle course using the Moodle restoration process. Such approaches result in semantics adaptations and semantics losses during their internal mappings because of the gap between the instructional design language, the specific learning design capabilities as well as features of the targeted LMS.

Other research [13] shows that model transformations techniques from the MDE theories and tools can be useful to translate a designer-centered and LMS-independent learning scenario to an LMS-specific one. Nevertheless, they also highlighted the complex transformation model to specify, the LMS metamodel to capture, the semantics losses during translation, and the requirement of an LMS-dedicated tool for embedding the scenarios into the LMS.

2.3 Model Driven Engineering Within the Graphit Project

The project methodology consists in exploring how *Model Driven Engineering* and more particularly *Domain Specific Modeling* [9] techniques and tools can be relevant and useful to help in developing learning design editors that (1) are focusing on learning design for a specific existing LMS, (2) are enough expressive for abstracting the LMS's implicit learning design, and (3) are machine-readable, or *executable*, to be fully traduce into first LMS implementation settings.

Briefly, MDE is a software development methodology which focuses on creating and exploiting formal domain models and meta-models, rather than on producing code [23]. MDE is also a large research field about specifying/executing/transforming/composing (meta-)models. It comes with many specific tools to support all these activities. DSM can be considered as a specific MDE process. It involves the systematic use of domain-specific languages. These languages tend to support formal higher-level abstractions in contrast to semi-formal general-purpose modeling languages like UML.

The approach and architecture we propose is different from other existing approaches. We propose an LMS-dependent architecture that only focuses on one existing LMS in order to provide instructional design languages that will be specified and tooled. Our idea is to conduct the platform abstraction in accordance with the formalisation of future learning scenarios. We do not aim at extending the LMS semantics with new add-ons/plugins, enriching it with more pedagogical-oriented features. Our objective is to support learning scenarios specification in conformance with the LMS semantics (its abilities as well as its limitations). Furthermore, we do not aim at only providing a notation layer on top of the LMS metamodel. The results of past experiments [14] show that the best solution (expressiveness/LMS compliance ratio) relies on extending the LMS metamodel. However, it requires a strong metamodeling expertise to reduce the developing cost while restoring the LMS compliance. This solution also highlights the importance to drive the expressiveness (and semantics) extension of the initial metamodel with the binding capacity. This paper focuses on our further results and propositions about this issue.

By extending the LMS metamodel we also extend the abstract syntax of the instructional design language and thus lose the LMS-compliance format. We plan to restore it by DSM (Domain-Specific Modeling) techniques (weaving and transformation models). We aim at guaranteeing that learning scenarios could be fully operationalized into the LMS without semantics losses. Our approach can take advantage of this LMS-dependance but it has also the disadvantage to be restricted to one LMS and one of its versions. The LMS instructional design semantics has first to be identified and formalized as a domain metamodel. This metamodel drives the elaboration of an XSD (XML Schema Definition) schema that will be used as a format reference for the API to develop. This API will be used through an import facility available to teachers-designers in their LMS courses. Its function is to parse the XML-based scenario and fill-up the LMS database. According to DSM techniques and tools (like the EMF/GMF ones for example [15]), the visual instructional design language will be composed of an abstract syntax (based on an extension of the LMS metamodel) from which the graphical, tooling and mapping models will be derived. The editor will also be developed using the code-generation feature of DSM tools. The produced scenarios have to be compliant with the initial LMS meta-model to be deployed by the API. We propose then to run two kinds of model transformations. The first one will consist of various, fine-grained transformations that will be run during design-time: it will show some LMS mappings to teacher-designers in order to help and guide them in the design process (partial compliance). The second transformation, unique and large, will be used as an export feature (after design-time) and will restore a full-compliance to the LMS metamodel.

The main challenge of this project is to create enough abstraction from the LMS instructional design semantics to provide teachers with some pedagogically-sound higher design building blocks. The LMS expressiveness and limitations have to be overcome in order to offer teachers some instructional design mechanisms closer to their practices and needs about specifying and sequencing learning activities. Although the GraphiT project deals with different LMSs for guaranteeing the reproducibility of its results, we focus primarily on the Moodle platform which is the most popular open-source LMS.

3 Collect and Analysis of Requirements and Needs

We evaluated several theoretical sources [16] as well as we realized practical exchanges with pedagogical engineerers in order to sketch our proposition orientations. In addition, we decided to conduct a larger survey with complementary interviews to verify our initial assumptions and to collect feeback about our project orientations and positions. It also allows us to identify more precisely end-users' practices, needs and learning design tools requirements about the Moodle LMS.

3.1 Overview of the Survey

We conducted an online survey that was diffused through international French-speaking higher education institutions during a 4-week period. This survey addressed teachers and pedagogical engineers using existing LMSs. The survey was composed of 21 mandatory questions, most of them accepting multiple answers. Some questions were conditioned to the selection of previous specific answers. For example, the first 8 questions (relative to the global design of courses) are LMS-independent whereas the other ones were only available to people using Moodle. We received and analysed 208 results. We only sketch here the most noticeable and relevant points in relation to the focus of this paper.

74 % of those polled use an LMS in addition to their face-to-face courses (32 % only for this purpose), 52 % for distant courses and 37 % during the face-to-face sessions. Main uses of the LMS concern the document transmission (91 %), collection of works (52 %), support for collaborative activities (47 %), evaluations (47 %), and new pedagogical practices (58 %). On average, half of those polled considered having explored the LMS alone. Those who did not consider themselves as novices (56 %) stated that they had improved their LMS knowledge on their own at 73 %.

Although half of Moodle users consider that the global user-interface of a course is easily understandable, only 33 % consider that the form-oriented parameterization screens are understandable. From a learning design perspective, they sketch all (38 %) or part (37 %) of the learning scenario before setting-up the equivalent course upon Moodle. 43 % of this sub-population have met some difficulties during this manual step and have felt constrained in adapting their initial scenarios and intentions (12 % failed to adapt the scenario). A majority of Moodle designers use the basic functionalities like the move left/right (64 %), the hide/show (84 %) parameters. Half of the group graded students' productions and use Moodle's groups and groupings when required. 62 % used the restrict access settings but only 34 % the activity completion. 15 of 22 Moodle standard functionalities are not well known by an average of 50 % (sometimes more) of answerers, whereas the 7 others are regularly used. The *Forum* is largely preferred to the *Chat* feature to foster communication. For the setting-up of exercices, *Assignment* (47 %) and *Quiz* (37 %) are preferred to *Hot Potatoes* (15 %) or *Lesson* (19 %). The *Wiki* is the most preferred collaborative tool (23 %) among others (*Journal* 8 %, *Workshop* 8 %).

3.2 Interviews Analysis

From most relevant answerers that agreed to be contacted we conducted 20 one-to-one interviews, mostly by distant devices. Interviewees were selected depending on their instructional design expertise about the Moodle platform.

They agree that Moodle is useful for simple pedagogical objectives but is time-consuming for elaborating more complex learning situations. Settings screens are considered too complex and difficult to handle. These screens mix pedagogical and technical parameters. They require to test and observe the pedagogical implications of all combinations. Some interviewees stated that they encourage to use default parameters and then, hinder the setting-up of more complex activities.

A majority of interviewees accept the idea of both an external learning design editor dedicated to Moodle and an *import* block available through the Moodle internal design space to automatically set-up the course (the external feature allowing offline designs and the graphical notation helping to visualize the scenario at design-time). They approve the approach, emphasising its relevance if templates or concrete cases about pedagogical uses of Moodle tools can be handled within the editor. They highlight the need for a language/editor covering large pedagogical uses but without being too generic. Some of them consider important to continue using the editor for adapting the scenario after the import step although they agree that a round-trip use of both editor and Moodle can be an obstacle.

One issue highlighted is that practitioners did not expressed common design practices, as we expected them to, mainly because of the heterogeneity of their Moodle expertises and pedagogical backgrounds. Nevertheless they have in common to think about Moodle tools according to their basic pedagogical uses. Indeed, they all point the heavy parameterizations of tools and resources and the need for having an abstract view of what are the pedagogical uses in order to help and guide them in selecting and configuring the right implementation activities.

3.3 Requirements for a Learning Design Language and Editor

From all these practitioners feedback we listed some specific requirements for our Moodle language/editor to develop. First, they mentioned the need for the graphical authoring-tool to allow designers to select pedagogical blocks on top of the LMS semantics as well as with Moodle building blocks to compose with. In their mind, the editor will not have to strictly follow a top-down process from abstracted specification elements to implementation one expressed in terms of Moodle; abstractions from Moodle and its own concepts should be mixed up together according to practitioners' expertise about instructional design (**specification and implementation concepts mix**). Secondly, they are interesting in the idea that mappings from pedagogical design blocks to Moodle concepts can be showed to practitioners (**default mapping**) and adapted if required (**mapping adaptation**). This design approach could help practitioners in the appropriation of the pedagogical constructs and guide them in designing more abstract learning scenario while mastering the translations into LMS elements.

Another design point highlighted (**declarative non-visible information**) is about the possibility to design and declare within the learning scenario some information that do not required to be mapped into LMS concepts or just mentioned as non-visible labels (for students/tutors) for the teacher himself: information about the face-to-face sessions mixed up with the LMS-centered ones, about pedagogical strategies or pedagogical objectives, about activities to realize on the LMS at a specific runtime moment according to concrete data (enrolled students, dates, etc.). Finally, another design need was to help teachers in sequencing the course in more advanced structures (choices, sequences) with elements showed one-by-one according to their progress (**advanced activity structures**). Indeed, these can be done manually but it requires to parameterize many low-levels and technical-oriented properties (achievements, restricted access conditions...) that they would appreciate not to have to set up by themselves.

4 Abstractions Based on the LMS Metamodel

We plan to study how the LMS semantics about instructional design could be abstracted from two perspectives: a theoritical one, generalizable to different LMSs, and a practical one about the special case-study of the Moodle LMS. We chose to follow a bottom-up approach by focusing at first on the Moodle LMS. According to practitioners' needs, the abstraction could consist in raising the recurrent LMS uses supporting some learners and/or teachers activities. From an activity theory perspective [17,18], such activities should involve LMS's bindings of subject, objects, tools/artefacts, community, division of labor and rules. Because our survey and interviews highlight a special need to ease the parameterization of Moodle tools and resources for setting-up activities, we decided to focus at first on raising these tools and resource semantics, and to study later the other aspects.

The following sections present these abstractions in relation with their formalizations for the Moodle LMS. The metamodel from Fig. 1 can be considered as part of the general abstract syntax of the instructional design language to be developed. This part focuses on the abstraction of Moodle tools and resources.

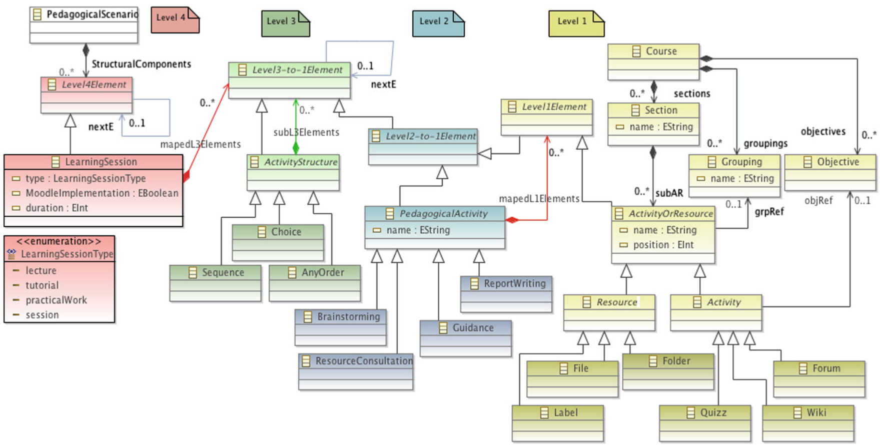

Fig. 1. The abstract syntax of an instructional design language on top of the Moodle metamodel (Color figure online).

4.1 Tool-or-Resource-Based Pedagogical Activities

We define an LMS-abstract pedagogical activity as an *encapsulation of parameters a teacher has to set-up when using a tool (or resource) for a specific pedagogical use.* From a single tool, for example a forum, a teacher can design several pedagogical use, depending on its configuration: to provide news to students, to set up group work, to propose a peer reviewing activity, etc.

Because several LMS functionalities can be used for the same pedagogical purpose, we have to find the discriminatory criteria that can guide to identify the right tool and default mapping (as well as the relations to objectives, resources, groupings, etc. that are involved in the right setting-up of the pedagogical activities).

To be used appropriately, this first abstract block requires a name, a description, and specific properties (the former discriminants), set at design-time by practitioners, that will drive the default mapping. For example an exchange activity, involving student communication, could either rely on a forum or a chat, depending on a synchronous property. The mappings will not be limited to the parameterization of a tool. It will also impact some other elements in relation with the tool/resource: grades, objectives, groupings, restriction access and achievements rules, etc.

4.2 Activity Structures

According to [19], successful implementation of an online course that is facilitated by an LMS needs careful planning, including structural strategies in the design of the course. In order to ease and assist the practitioners when assembling and setting-up combinations of activities or resources we propose then usual structural elements (selection, sequence, conditional activities, etc.). These blocks will be composed of activities or other activity structures. Every instructional design language feature some of them. In the case of Moodle they will be concretely translated as complex combinations of *labels* (stating the structure name, kind and use for users), shifted content (*move left/right* feature) according to the activity structure components in the learning scenario. After various translations and mappings until reaching the LMS low-level elements, all its content will be parameterized (*restrict access*, *visibility*, *achievement*...) with appropriate properties in order to set up the desired behavior.

4.3 Instructional Design Language Abstract Syntax

The abstract syntax of the Moodle-centered instructional design language is composed of four levels. Figure 1 illustrates our proposition with a graphical representation of the ecore domain model (the EMF metamodel format).

Level 1 fits the Moodle metamodel. Readers have to consider Fig. 1 as a part of the whole metamodel. Only important structural relations and concepts are depicted because of our current interest. *Level 1 elements* (restricted to the Moodle *activities* – name for tools given by Moodle — and resources) can be directly used by teachers-designers and parameterized for building a learning session. From the Moodle metamodel point of view these elements require a global *Course* and a *Section* container to be attached to. In the extended metamodel they will be specified at first as child of *level 4 elements*. The model transformation, at post-design-time, will deal with restoring a model in full-compliance with the Moodle metamodel: creation of the global *Course* instance, *Section* instances, attachment of all the corresponding Moodle elements according to the orders and positions deductible from the source scenario.

Level 2 includes our pedagogical activities. They are composed of *Level 1 elements*, i.e. Moodle activities and resources. Level 3 captures the activity structures. The activity structures are composed of *Level 3 elements* specified during the design-time. Finally, the fourth level is the contextual level focusing on the global structure of the learning session in relation to the different face-to-face, complementary, distant sessions or other teacher-defined customized sessions.

Such *Level 4 elements* rely on the Moodle *section* concept. Indeed, Moodle only proposes sections into the space of the course for aggregating the tools and resources. However, designers have at their disposal an *indentation* feature (*position* property in the Moodle metamodel) to shift activities and resources in order to visually indicate their collective relationships. This *position* property will be used by the dynamical mappings, in order to position the corresponding elements in accordance to the source element position in the global learning scenario.

The relations with a red composition indicate that the content will not be displayed in the future concrete syntax (notation) as nested elements but will appear in another sub-diagram where the parent container will be the root canvas. Differently, the green composition indicates that content will be showed as nested elements of the parent container in the same diagram. Finally, the *nextE* reflexive relation allows, by inheritance, to provide a previous/next information to sequence the various elements within their dynamic pedagogical context (the ordering concerns the child elements sharing a same *Level Element* parent).

The *leaf* meta-classes from Fig. 1 (dark elements) sketch some examples of future elements. They are on purpose not showing their attributes (for ease of reading). However each of them owns specific properties in accordance with the different in-progress formal specifications we are studying about the Moodle instructional design semantics, pedagogical activities, and activity structures.

Overview of Our Instructional Design Tool. The proposed authoring-tool will directly propose to practitioners the *level-4 elements* in the tool palette. Indeed, these elements are required to map to Moodle sections in order to sequentially structure the course skeleton. Sessions that do not rely on Moodle features can also be described if designers need an overall view of a global module/course larger than the ones involving the use of an LMS. Other *level-4 elements* will then open an empty sub-diagram when double-clicked. It can then be used to arrange *levels 3-to-1 elements* from the new palette. Indeed, practitioners can then choose the method (top-bottom, bottom-up), the description level (specification versus implementation) and the elements to select, combine and adapt. Pedagogical activities can be opened up as another sub-diagram containing the default mapping to *levels 1 elements*. Every mapping can be adapted and modified by deleting/adding new elements (according to those accepted under the parent element) or modifying the elements properties. This layer-oriented notation and functionalities fit the practitioners' need depicted in Sect. 3.3.

5 Main Abstraction: Pedagogical Activities

5.1 Identifying Pedagogical Activities

For identifying the most appropriate tool from a specific pedagogical activity, we followed these three steps: (1) analysis for each Moodle tools of its recurrent uses (bottom-up method), (2) identification of tools offering common uses (top-down method), and (3) specification of discriminating criteria to drive the selection of a suitable tool. Moodle 2.4 offers 7 resources (*Book*, *Page*, *Label*, *IMS content package*, *File*, *Folder*, and *URL*) and 13 activities (*Forum*, *Database*, *Glossary*, *Assignment*, *Lesson*, *Quiz*, *Workshop*, *SCORM package*, *External tool*, *Choice*, *Survey*, *Wiki*, and *Feedback*). We have study their recurrent uses. We notice that some activities/resources can be diverted to serve for different uses. For example, everyone knows that the *Forum* is used for discussion reasons but it can also be used to allow students to introduce themselves in a course or to consult a Frequently Asked Questions (FAQ) or to share documents between learners. After looking at all Moodle's activities/resources uses, we have identified those supporting the same uses. Three tools can be used to consult a FAQ: the Forum, the Wiki, and the Glossary.

We have then specified discriminating criteria to help a teacher in deciding which tool he must use if he has many choices. We chose $m \times n$ matrix A format to present these discriminating criteria (A has m rows and n columns, first row and column are headers and not part of the matrix data) according to seven rules:

R1. The pedagogical activity name is only from a teacher perspective if no students are concerned (=with parameter *hide* on). For example, for a survey, we choose the expression "answer a survey" (students viewpoint) instead of "create a survey" (teachers viewpoint). Note that A_{11} presents this pedagogical activity.
R2. Tools participating to the realization of the activity are the elements $A_{12} \ldots A_{1n}$.
R3. Discriminating criteria are the elements $A_{21} \ldots A_{m1}$.
R4. Discriminating criteria are expressed as much as possible as a pedagogical question designers have to answer by *Yes* or *No*.
R5. Cells intersecting a discriminating criterion and a tool must embed all answers that can implied to choose this tool (*Yes/No* are both possible if this criterion is not directly discriminant for this tool, i.e. the tool can support both pedagogical cases).
R6. A valid discriminating criterion must cause at least one different answers for one tool.
R7. The matrix is terminated if there is no similar combination of answers for two tools.

An unachieved matrix indicates to experts that they have to add one more discriminating criteria and verify again the rule R7. Table 1 shows an example of identification matrix for the pedagogical activity (PA) "Answer a poll". Four Tools can support this activity: *Quiz* (T1), *Choice* (T2), *Feedback* (T3), and *Survey* (T4). Experts have found 7 discriminating criteria. Each criterion is presented in the form of a question:

– (C1) More than one question?
– (C2) Only multiple choice questions?
– (C3) Pre-populated with questions?
– (C4) Time limit?
– (C5) Anonymous?
– (C6) Graded?
– (C7) Feedback after submission?

Table 1. Example of identification matrix.

PA	T1	T2	T3	T4
C1	Yes/No	No	Yes/No	Yes
C2	Yes/No	No	Yes/No	Yes
C3	No	No	No	Yes
C4	Yes/No	No	No	No
C5	No	No	Yes/No	No
C6	Yes	No	No	No
C7	Yes	No	Yes	No

In Table 1, we have three different answers that can imply these four tools: Yes, No, and Yes/No. For example with a survey (T4), we can have more than one question (A_{25} = Yes), only multiple choice questions are allowed (A_{35} = Yes), it is a pre-populated survey with questions (A_{45} = Yes), it can not have a time limit/countdown timer for students' navigation (A_{55} = No), it is always nominative (A_{65} = No), it can not be graded (A_{75} = No), and students can not have a feedback after their submissions (A_{85} = No). Note that a designer can reply to C1, C2, C3, C4, C5, C6, and C7 in any order. Some combinations cannot lead to a specific tool choice for two reasons: (1) a non-valid combination, or (2) a non-response to all questions. In the first case, the experts will be notified to adapt their pedagogical choices while in the second case they will be asked to precise more choices.

Such identification matrix has to be completed by additional information in order to precise the general (whatever the answers that guide the binding like a tool name) or contextualized (depending on some specific answers like a tool format) parameters for the related LMS activity or resource.

5.2 Formalization Through a Model Weaving Technique

According to our Model Driven Engineering research framework, we can use model transformations to achieve the mappings specified by experts. The transformations will be run at design-time, to add mapped elements to the model and populate the sub-diagrams. Such transformations are complex (proportionally to the mapping complexity) and numerous, thus costly to write.

We on purpose propose to use the model weaving technique we studied in [20] to capture the mapping semantics in dedicated weaving models and automatically generate models transformations. From a practical viewpoint, thanks to the matrice and additional information from an LMS expert using our method and formalisms depicted in Sect. 5.1, an engineer will formalize the mappings in a weaving model, using a tree based editor. He can then run a generic *High Order Transformation* (HOT) that will generate the concrete "mapping transformations". These final transformations can then be integrated within the graphical editor to be automatically run at design-time when teachers-designers will specify the pedagogical activity properties.

The weaving models can be expressed using a weaving language, based on a generic weaving metamodel we designed. This weaving metamodel defines the "syntax" of the mapping/weaving model. Each mapping (or binding) has one *source* element and one or several *targets* (chosen from the extended instructional design metamodel). Targets can have conditions on whether they have to be instantiated or not, attributes can be set to specific values (also with conditions). Figure 2 is a screenshot of the weaving editor. It is used to formally specify as a weaving model the corresponding binding specified by LMS's experts. Concretely, the left part of the figure should concern level-2 elements of our instructional design metamodel for Moodle (1) whereas the right part should only concern level-1 elements, i.e. Moodle elements. Because our instructional design metamodel includes the Moodle one, source and target metamodels

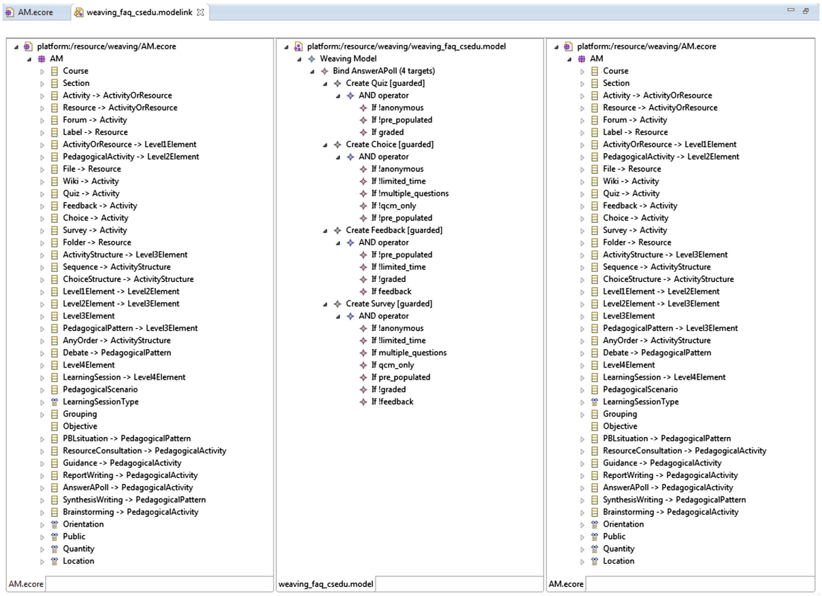

Fig. 2. Screen caption of our weaving tool for formalizing the bindings.

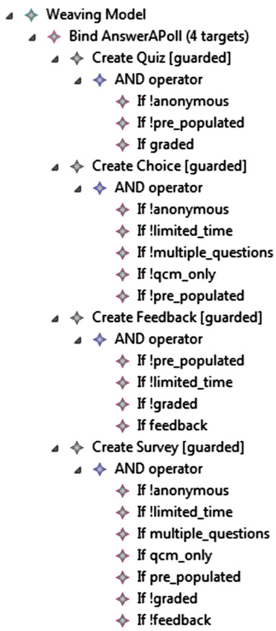

Fig. 3. Example of resulting weaving model (tree-based representation of a concrete XML file).

involved in the weaving are the same. The central part of the figure is the concrete tree-based editor for specifying bindings.

Figure 3 is an example of weaving model related to the binding example from the Table 1. It specifies the corresponding translations for all possible combinations by using AND/OR/! operators. Such weaving model is realized by following the matrice formalism, tool by tool. Informations about the tools parameterizations are deduced from the additional informations given by experts.

We used languages and tools from the Epsilon [21] project to build a software framework fulfilling our model weaving requirements. This project is compliant with the Ecore formalization of metamodels we already used to formalize the various metamodels we illustrated. This Ecore format is from the Eclipse Modeling Framework [15]. Weaving models are edited through ModeLink, a three pane editor displaying the source and target metamodels in side panels (which are the same in our use case). The final "mapping" transformations are expressed using Epsilon Object Language (EOL), and are generated through a Model-to-text transformation using EGL language. This last transformation replaces the HOT traditionally used in model weaving environments.

6 Example of a Learning Scenario

We on purpose propose to illustrate our proposal by formalizing a very simple but representative learning scenario for the Moodle LMS. We propose at first a brief textual description, then the equivalent specification as a model conformed to the dedicated metamodel we proposed in Sect. 4 (Fig. 4 is a screenshot of the EMF-tree-based model editor).

6.1 Description and Formalization

The learning scenario is composed of two learning sessions. The first one is a *lecture* session for which the teacher only want to provide learners with a *Resource consultation* corresponding to his face-to-face course material. This pedagogical activity has the *quantity* property set to "one" and the location set to "local". These properties will lead the dynamic mapping process to add the *File* Moodle element to the scenario (Fig. 5).

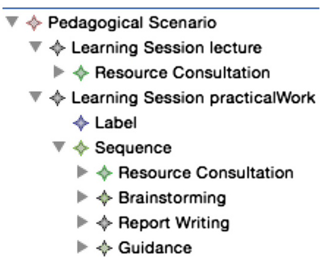

Fig. 4. Example of simplified learning scenario composed of elements from the 4 levels.

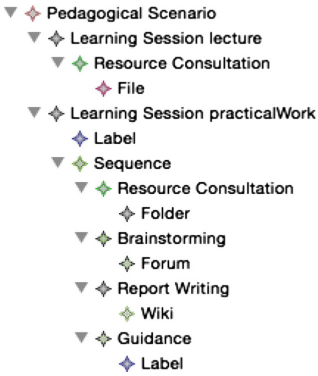

Fig. 5. Same example of simplified learning scenario with generated contextualized tools and resources bindings.

The second learning session is a *practical work* that the teacher wants to realize in face-to-face within a computerized classroom. He would like to use the Moodle platform for supporting a *sequence* activity structure embedding 4 sub-components. The first one is another *Resource consultation*. This time, the properties set to "many" (quantity) and "local" (location) by the teacher will

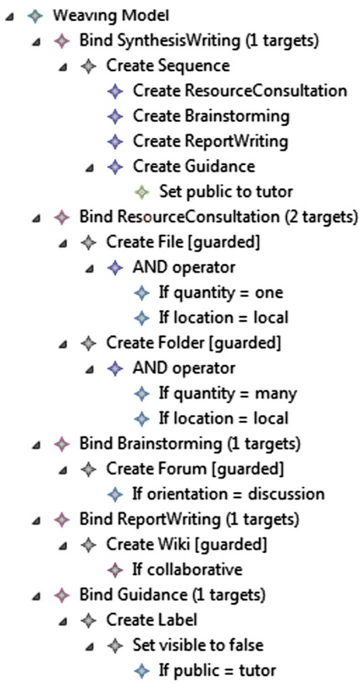

Fig. 6. Example of weaving model specifying mappings from Fig. 4.

lead the transformation process to add a *Folder* tool. The second sub-element is a *Brainstorming* pedagogical activity. Its *orientation* property set to “discussion” leads to propose a Forum tool. Similarly the third one is another pedagogical activity *Report writing* leading to a *Wiki* tool because of the *collaborative* property set to “true”. Finally the fourth sub-component is a *Guidance* activity that aims at reminding the teacher to evaluate the synthesis in the wiki. Thanks to a *public* property set to “tutor” it leads the mapping process to set the corresponding *Label* to be invisible (*visible* = “false”) to students (it will only be displayed to the teacher).

The teacher can change at any time the activities properties, leading to other mapping adaptations. He can also manually delete the mapping elements, rearrange their order, or add some other elements. Figure 4 shows a global overview of the learning scenario elements including all the automatic mappings according to the various properties and values (not depicted within the figure).

6.2 Prototype of the Learning Scenario Editor

We are currently working on the development of a prototype adding a notation layer on top of the abstract syntax we propose for the Moodle-centered instructional design language. We choose for now the Sirius tooling [22] because it allows to quickly define custom multiview for workbenches with less technical knowledge compared to the well-known GMF tooling (from [15]). The notation, or concrete syntax for our instructional design language, is derived from the abstract syntax formalized as an Ecore metamodel. Sirius also facilitates the development of

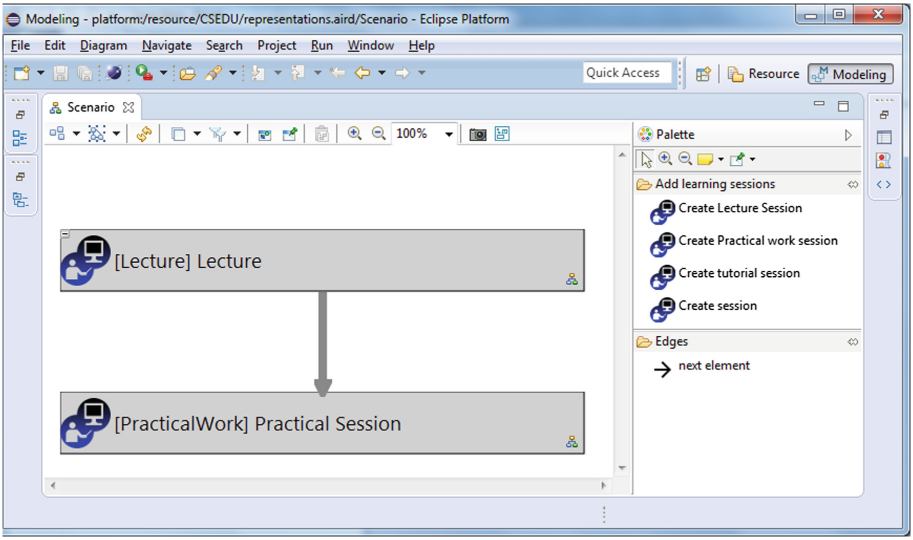

Fig. 7. Screenshot of a session diagram (level 4) in our current prototype.

dedicated graphical tools by generating most of features (diagrams, trees, tables, etc.) from the sirius-specific model we build when using it. It reduces the cost and complexity of developing a graphical editors.

We succedeed in integrating the mappings transformations within this prototype. For now, when a user double-clicks on a session within the first level diagram (depicted in Fig. 7), it opens a new diagram where he can mix elements from levels 1 to 3 according to his Moodle expertise (Fig. 8). Pedagogical properties of level-2 elements can be set at this stage. When these level-2 elements are double-clicked, a transformation process is launched for checking all transformation rules automatically generated from the weaving models we produced. The execution of an eligible rule modifies at run-time the current scenario by adding the corresponding binding towards Moodle elements (level-1). Figure 9 shows resulting mappings. The result is part of the pedagogical scenario: it can be modified by adding/editing/removing new level-1 elements. Mappings can also be updated if a user changes the pedagogical properties of a level-2 element.

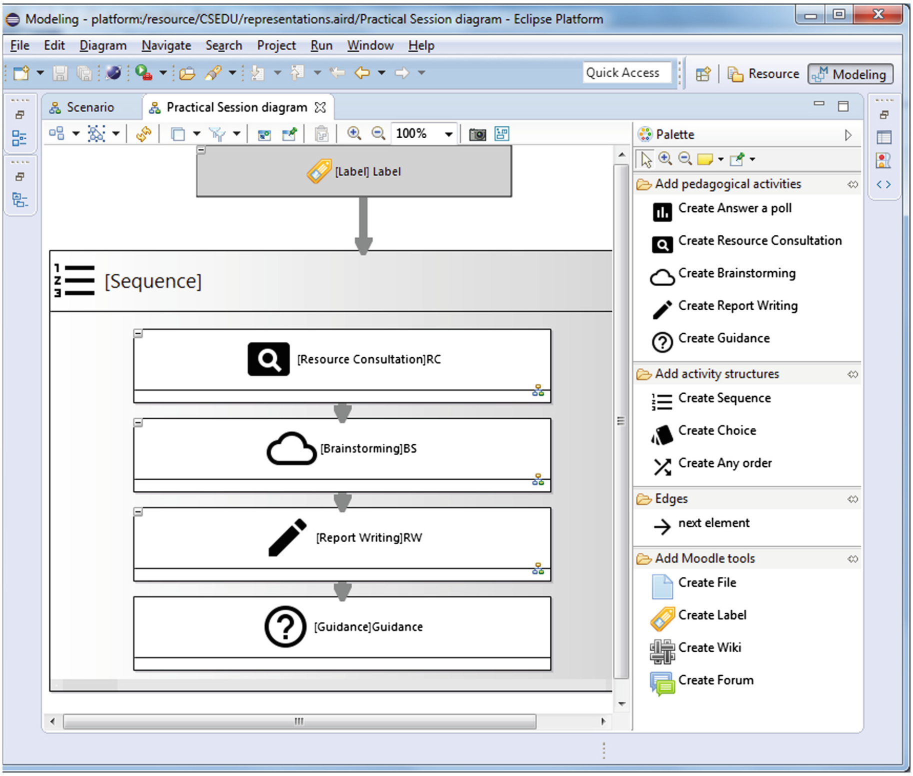

Fig. 8. Screenshot of an activities diagram (levels 3, 2 and 1) in our current prototype.

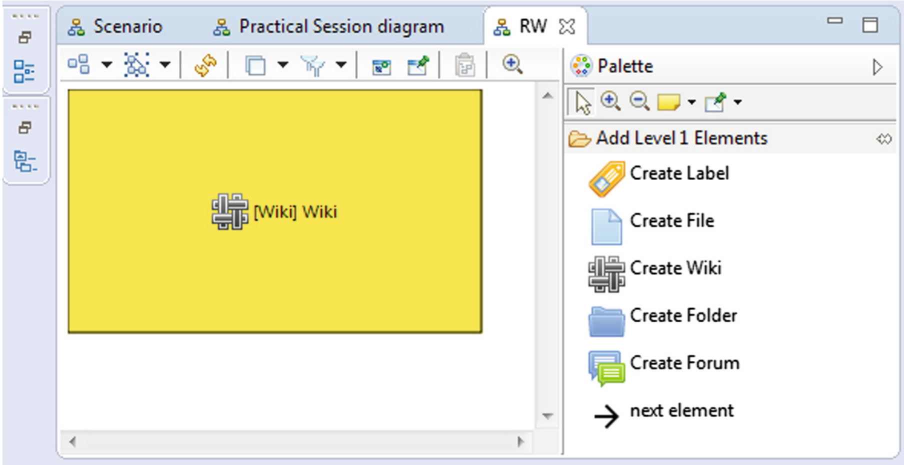

Fig. 9. Screenshot of a moodle diagram (level 1) in our current prototype of editor.

7 Conclusions

7.1 Tools Uses as a First Abstraction

We proposed a specific LMS-centered approach for raising the pedagogical expressiveness of LMSs implicit learning design semantics. We showed how the LMS low-level parameterizations could be abstracted in order to build higher-level building blocks that capture some recurrent tools uses into pedagogical activities. We also proposed a specific method for helping and guiding LMS experts to describe how these activities should be binded to appropriated tools or resources. In addition, we propose a specific model weaving solution for formalizing these mappings. These resulting weaving models will drive at run-time and in real-time the automatic translations when using the authoring-tool. Based on a Moodle application, we presented and illustrateed our approach by formalising the abstract syntax of a Moodle-dedicated instructional design language following a specific 4-levels architecture. We used some illustrative examples, as well as an overview of our current prototyping editor, to concretely argue and verify our propositions.

7.2 Ongoing Work and Future Perspectives

We are working on integrating groups and pedagogical objectives in both learning design language and prototype editor. The objectives could be linked to *Level 4-to-1 elements* and mapped to Moodle outcomes, contained by the root *Course*, labels, or description fields depending on its status (goals/competencies for teacher or activities objectives for learners understanding). Also, roles or groups refer to the division of labour in the learning scenario. Mappings to the Moodle concepts of *Group* and *Grouping* could be considered.

The 4-levels metamodel extension we propose breaks compatibility of the learning scenarios with the LMS format as it differs from the platform metamodel. We plan to restore it using a global model transformation (written with the *Atlas Transformation Language*), available as an export feature of the authoring tool.

We are planning an experimentation of the prototype with end-users (teachers), once it has reached a stable enough version. The main objective is the validation of the language, along with the design approach, more than the tool itself (ergonomy or user experience). By providing teachers with only general guidelines about the scenario to produce, we would like to evaluate how they are able to design a pedagogically sound course with the editor. We are interested in observing which abstraction levels and elements they will use, if they are following a top-down or bottom-up approach, if they will use the default-mapping feature and other specific features we propose.

References

1. Garrisson, D.R., Kanuka, H.: Blended learning: uncovering its transformative potential in higher education. Internet High. Educ. **7**, 95–105 (2004)
2. Ormrod, J.E.: Human Learning. Pearson College Division, Upper Saddle River (2011)
3. Alario-Hoyos, C., Munoz-Cristobal, J.A., Prieto-Santos, L.P., Bote-Lorenzo, M.L., Asensio-Perez, J.I., Gomez-Sanchez, E., Vega-Gorgojo, G., Dimitriadis, Y.: GLUE!-PS: an approach to deploy non-trivial collaborative learning situations that require the integration of external tools in VLEs. In: 1st Moodle Research Conference, Greece, pp. 77–85 (2012)
4. Katsamani, M., Retalis, S., Boloudakis, M.: Designing a moodle course with the CADMOS learning design tool. Educ. Media Int. **49**, 317–331 (2012)
5. Dougiamas, M., Taylor, P.: Moodle: using learning communities to create an open source course management system. In: The World Conference on Educational Multimedia. Hypermedia and Telecommunications, Waynesville, USA, pp. 171–178 (2003)
6. IMS Learning Design specification. http://www.imsglobal.org/learningdesign/index.html
7. Burgos, D., Tattersall, C., Dougiamas, M., Vogten, H., Koper, R.: A first step mapping IMS learning design and moodle. J. Univers. Comput. Sci. **13**, 924–931 (2007)
8. Berggren, A., Burgos, D., Fontana, J.M., Hinkelman, D., Hung, V., Hursh, A., Tielemans, G.: Practical and pedagogical issues for teacher adoption of IMS learning design standards in moodle LMS. J. Interact. Media Educ. (Advances in Learning Design, special issue) (2005)
9. Kelly, S., Tolvanen, J.-P.: Domain Specific Modeling: Enabling Full Code Generation. Wiley, Hoboken (2008)
10. Advanced Distributed Learning: The SCORM specification. http://www.adlnet.gov/scorm/
11. Botturi, L., Derntl, M., Boot, E., Figl, K.: A classification framework for educational modeling languages in instructional design. In: 6th IEEE International Conference on Advanced Learning Technologies, Kerkrade, The Netherlands, pp. 1216–1220 (2006)

12. Moodle Official Website. https://moodle.org
13. Abdallah, F., Toffolon, C., Warin, B.: Models transformation to implement a project-based collaborative learning (PBCL) scenario: moodle case study. In: 8th IEEE International Conference on Advanced Learning Technologies, pp. 639–643. IEEE Computer Society, Washington DC, USA (2008)
14. Loiseau, E., Laforcade, P.: Specification of learning management system-centered graphical instructional design languages - a DSM experimentation about the Moodle platform. In: 8th International Joint Conference on Software Technologies, pp. 504–511. Scitepress, Reykjavik, Iceland (2013)
15. Eclipse Modeling Project Official Website. http://www.eclipse.org/modeling/
16. Conole, G., Dyke, M., Oliver, M., Seale, J.: Mapping pedagogy and tools for effective learning design. Comput. Educ. **4**, 17–33 (2004)
17. Engestrom, Y.: Learning by Expanding: an Activity Theoretical Approach to Developmental Research. Orienta-Konsultit Oy, Helsinki, Finland (1987)
18. Benson, A., Lawler, C., Whitworth, A.: Rules, roles and tools: activity theory and the comparative study of e-learning. Br. J. Educ. Technol. **39**(3), 456–467 (2008)
19. Gedera, D.S.P., Williams, P.J.: Using activity theory to understand contradictions in an online university course facilitated by moodle. Int. J. Inf. Technol. Comput. Sci. **10**, 32–40 (2013)
20. Loiseau, E., Laforcade, P., Iksal, S.: Model weaving and pedagogy mapping abstraction levels in instructional design languages. In: 9th International Joint Conference on Software Technologies. ScitePress, Vienna, Austria (2014)
21. Paige, R.F., Kolovos, D.S., Rose L.M., Drivalos N., Polack F.A.C.: The design of a conceptual framework and technical infrastructure for model management language engineering. In: 14th IEEE International Conference on Engineering of Complex Computer Systems, pp. 162–171. IEEE Computer Society, Washington, DC, USA (2009)
22. Sirius Project. http://eclipse.org/sirius/
23. Schmidt, D.C.: Model-driven engineering. IEEE Comput. **39**(2) (2006)

Personalisation in MOOCs: A Critical Literature Review

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Abstract. The advent and rise of Massive Open Online Courses (MOOCs) have brought many issues to the area of educational technology. Researchers in the field have been addressing these issues such as pedagogical quality of MOOCs, high attrition rates, and sustainability of MOOCs. However, MOOCs personalisation has not been subject of the wide discussions around MOOCs. This paper presents a critical literature survey and analysis of the available literature on personalisation in MOOCs to identify the needs, the current states and efforts to personalise learning in MOOCs. The findings illustrate that there is a growing attention to personalisation to improve learners' individual learning experiences in MOOCs. In order to implement personalised services, personalised learning path, personalised assessment and feedback, personalised forum thread and recommendation service for related learning materials or learning tasks are commonly applied.

Keywords: Personalisation · MOOCs · Literature survey · Adaptive MOOCs · Learning analytics · MOOCs personalisation

1 Introduction

Massive Open Online Courses (MOOCs) are an emerging area in technology-enhanced learning [1]. Even the first MOOCs course, Connectivism and Connective Knowledge 08 (CCK08), has attracted thousands of learners. It should be noted here, this online course was not announced as a "massive open online course", the term "massive open online course" was first introduced in 2008 by Dave Cormier to describe George Siemens and Stephen Downes' CCK08 online course [2]. The first MOOCs course was based on connectivism theory that addresses issues about connecting people and resources to construct knowledge. It emphasises the importance of providing social platforms to learners to support their interactions with the course content, rather than just transmitting knowledge to them [3]. This kind of MOOCs is later known as cMOOCs.

In 2011, Sebastian Thrun designed a MOOCs course on Artificial Intelligence at Stanford University. Pedagogically, this MOOC was different from the first MOOC. It is more teacher-centric in which learning goals and learning plans were predefined for potential learners. This kind of MOOCs is named as xMOOCs, and it is based on the behaviourist learning theory [4].

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Even though MOOCs are relatively a new trend in technology-enhanced learning, concerns on teaching and learning with MOOCs are still the same with those on online education [5, 6], for instance, how can MOOCs be pedagogically efficient to address different needs of its learners? Research attempts to address this issue are discussed further in Sect. 3. One proposed study is to provide MOOCs personalisation through educational data mining in order to improve learning experience in MOOCs. In this paper, the state of the art of personalisation in MOOCs based on a study on the related literatures is presented. The methodology is presented in Sect. 2. Analysis and findings are reported in Sect. 3 in order to identify the aspects of MOOCs' personalisation that are commonly addressed by researchers and those that are still not sufficiently look into. The existing personalisation approaches and report of the critical reviews on them are further investigated in the sub sections of Sect. 3. Based on the findings, suggestions on ways to improve the delivery of personalised learning in MOOCs are provided in Sect. 4. Section 5 concludes the study and presents suggestions for future work.

2 Methodology

In this work, we expanded our survey has been done in [7]. Available literature has been searched on several academic databases between 2011 and July 2015 with the keywords "MOOCs personalisation" and "adaptive MOOCs". Those digital academic databases are Google Scholar (GS), The British Journal of Educational Technology (BJET), American Journal of Distance Education (AJDE), Journal of Online Learning and Technology (JLOT), ISI Web of Knowledge (WoK) and IEEEXplore. The reason of starting with 2011 is that 2011 is the year in which both xMOOCs and cMOOCs have been discussed [4] and MOOCs have become rapidly and widely used in online learning as reported in [8]. While analysing literature, grey literature such as technical report and white papers are analysed along with peer-reviewed articles.

Table 1. Search results for the keyword "MOOCs personalisation".

	2011		2012		2013		2014		2015	
	S	R	S	R	S	R	S	R	S	R
GS	17	0	29	1	313	11	427	14	336	16
BJET	0	0	0	0	0	0	1	0	0	0
AJDE	0	0	0	0	0	0	4	0	0	0
JOLT	0	0	0	0	0	0	0	0	0	0
WoK	0	0	0	0	4	1	0	0	0	0
IEEEXplorer	0	0	0	0	0	0	0	0	0	0

Tables 1 and 2 illustrate the number of papers that have been retrieved, along with the number of relevant papers to the personalisation of MOOCs over the years based on the searched keywords "MOOCs personalisation" and "adaptive MOOCs", respectively. While the year 2012 is called and referred many times as "the year of the MOOC"[1], personalisation of MOOCs has been on the rise since 2013.

Table 2. Search results for the keyword "adaptive MOOCs"

	2011		2012		2013		2014		2015	
	S	R	S	R	S	R	S	R	S	R
GS	19	0	72	1*	422	18¶	623	17¶	453	18⌘
BJET	0	0	0	0	3	0	1	0	3	1
AJDE	0	0	0	0	0	0	2	0	0	0
JOLT	0	0	0	0	0	0	0	0	0	0
WoK	0	0	0	0	3	1*	4	0	0	0
IEEEXplorer	0	0	0	0	1	1*	5	3§	1	1

*1 same result with the other search
§2 results of them are the same with the other search
¶8 results of them are the same with the other search
⌘9 results of them are the same with the other research

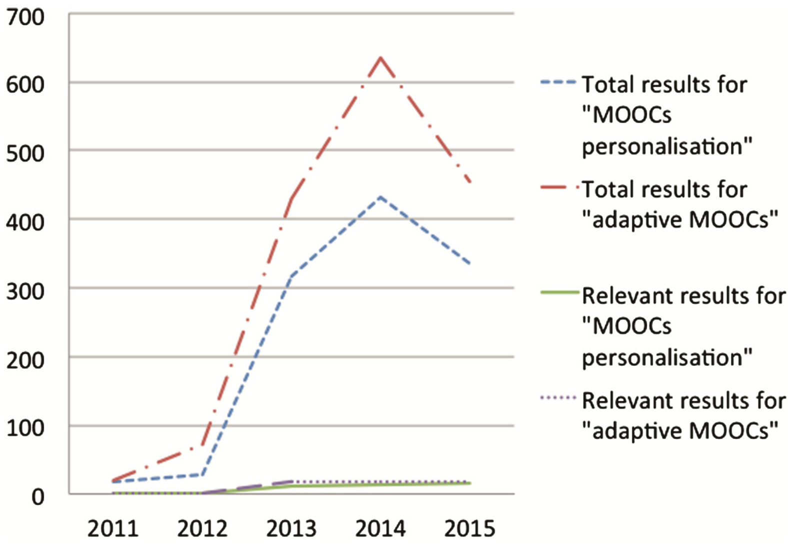

Fig. 1. The total number of papers and relevant papers by the searches for the keywords "MOOCs personalisation" and "adaptive MOOCs"

[1] http://www.nytimes.com/2012/11/04/education/edlife/massive-open-online-courses-are-multiplying-at-a-rapid-pace.html.

The data on the tables is visually interpreted on Fig. 1. It clearly illustrates that the amount of attention for personalised learning in MOOCs has drastically increased since 2013. The decrease in 2015 on the figure should not mislead the reader. The results in 2015 show only the first 7 months of 2015 and it is already higher than 2013. It could be higher than the total result in 2014 by the end of the year. In this respect, it cannot be claimed that studies on personalisation in MOOCs are on decrease.

Even though, the number of search results is over 600 papers (see Fig. 1), relevant papers are only a few among them (66 papers in total by 2015 July). Papers on studies regarding adaptive online education systems, and other issues related to MOOCs are also retrieved along with papers on mass personalisation in MOOCs with these keywords. However, the relevant papers only indicate studies discussing mass personalisation.

This work reported in this paper only considers the relevant papers for analysis. The analysis is organised according to the purposes and scoped of the studies, and the personalisation or adaptation techniques used.

3 Data Analysis

Once the redundant papers are eliminated from the collection of relevant papers, it is observed that some papers rhetorically indicate needs for personalisation in MOOCs while some others attempt to develop personalisation services in MOOCs. Therefore, the relevant papers are clustered into three categories in this study:

1. NEEDS: Represents the ‘Need for personalisation in MOOCs’. This category of research papers indicates the need or opportunity for MOOCs personalisation. They mainly report findings that lead to the need for personalised learning in MOOCs. However, the papers in this category do not propose any project, framework or system for designing or implementing personalisation in MOOCs.
2. PROPOSALS: Represents the ‘Plan to implement personalisation in MOOCs’. This category of research papers expresses ideas and proposals for personalisation projects in MOOCs. However, the plans for the intended personalisation systems have not yet been implemented.
3. IMPLEMENTATIONS: Represents the attempts for ‘Personalisation Service in MOOCs’. This category of papers expresses partly or fully implemented and experimented proposals for personalisation in MOOCs. However, majority of studies in this category are in progression state with no definitive outcome yet.

Figure 2 illustrates the number of papers in each category over the years. The figure denotes that only one paper emphasises the need for personalisation in MOOCs in 2012 while 2013 is the year with the highest number of papers (13) calling for personalisation. In 2013, there are 5 descriptive papers on proposals for personalisation in MOOCs but only 3 papers proposed partly or fully personalised MOOCs functions in MOOCs learning environment. Generally, the number of papers in categories of Proposals and Implementations increases in 2014 and 2015 after the call for adaptive MOOCs in the previous year. The results show that there is a rapid growing of interest towards personalised and adaptive learning in MOOCs. Another case is recognised that some research initially categorised as Proposal is later developed and the outcomes reported as Implementation. For example, Fidalgo-Blanco et al. [9] put forward an adaptive system for MOOCs in 2013 and this article is reported in Proposal. The authors implement their system and reported in [10] in 2015 and this article is reported in Implementation. Even though only 2 studies were found during our investigation, this case shows that research on personalisation in MOOCs has progressed over years. Additionally, it might be assumed therefore that there will be experiments to be fully implemented in the coming years.

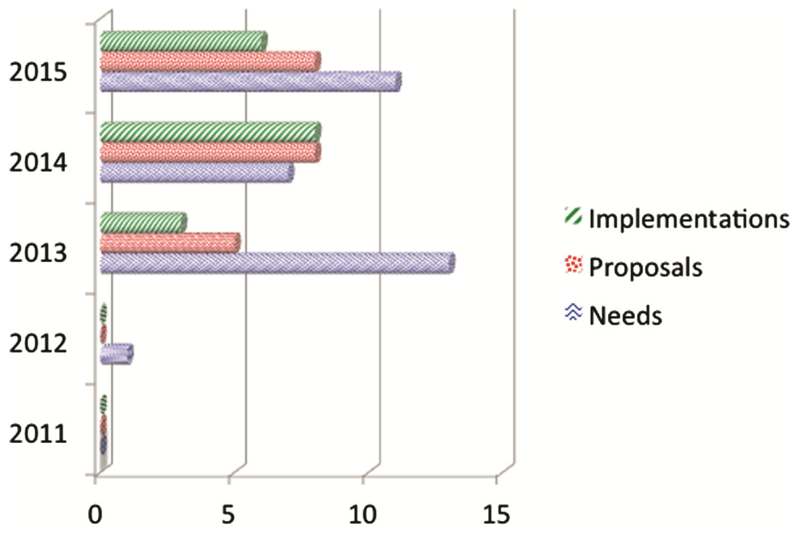

Fig. 2. The number of papers in each category over the years (Color figure online).

3.1 Category 1: Needs

The availability of the big data in MOOCs, and tools to perform learning analytics would make it possible for a personalised system to predict learners' learning behaviours and preferences in order to deliver personalised learning and assistance to MOOCs learners [17]. Commentators have shown interest in this since 2013. [11–16] indicate that a huge amount of human data can be collected through MOOCs. Shaw also [6] (2012) points out that this pool of human data could be used to create a human model in intelligent tutoring system (ITS) for MOOCs. Similarly, Yates [18] and Knox [19] highlight that data mining and data analytics for prediction could make MOOCs adaptive. Slightly on a different note, Kay et al. [20] predict that educational data mining and learning analytics should be applied for MOOCs' social network analysis to enable personalised learning in MOOCs. Kalz [21] further supports the argument by highlighting that these techniques could make MOOCs a more suitable technology to support lifelong learners. Additionally, Williams et al. [22] point out that collaborative and personalised learning could be supported through MOOCs with those techniques.

The importance of offering personalised learning in MOOCs is further expressed by the following researchers. For instance, Amo [23] believes that MOOCs should offer student-centred learning for effective and quality education in order to meet each individual learner's learning expectations in MOOCs. However, she emphasises that current pedagogy and design of MOOCs is not enough to improve students' outcomes. As there are many exciting and available pedagogies in technology enhanced learning such as peer assistance and assessments, social networking, and gamification, the author suggests for the incorporation of these pedagogies into MOOCs. This can be accomplished through the use of learning analytics and continuous monitoring of students' interactions so that automated assessment with instant feedback can be personalised to every student to improve quality learning in MOOCs. Yousef et al. [24] also consider using peer-assessments to deal with poor assessment system in existing MOOCs in cooperation with blended MOOCs.

Sanna and Anne-Maria [25] also discuss MOOCs pedagogy and personalising learning process to improve individual study plans in a collaborative learning community in MOOCs. Huggings and Smith [26] focus on the same approach to improve higher education by integrating MOOCs into formal higher education.

McLoughlin [27] and Knox et al. [28] address the current inefficiency of learners' feedbacks in MOOCs. They point out that MOOCs environment is convenient for offering personalised contents and feedbacks to learners based on their learning goals. This is because MOOCs provide learning flexibility and sense of independence between learners and teachers that are important when implementing personalisation in technology-enhanced learning. Ling [29] also similarly expresses that personalised and linked learning resources could be helpful for providing feedbacks and resource recommendation in order to overcome static design of MOOCs.

Additionally, Kalz and Specht [30] point out that the current MOOCs design does not consider the diversity of its learners. The authors suggest that building sub groups that share similar attitudes and interests could be a solution. The authors further indicate that the heterogeneity problem in MOOCs community is akin to the problem of learning network. The authors describe learning network as a connection of humans, actors, agents, institutions and learning resources organised for a learning program/course. To deal with diversity in learning networks, several services for learner support in learning networks should be utilised, such as placement support service (navigation support), a recommender service, and knowledge matchmaking service. By using these intelligent personalisation techniques, different needs and interests among diverse learners' community in MOOCs can be addressed. To further support the importance of addressing diversity among learners, Cavanaugh [31] whose work focuses on MOOCs assessments for credits for the post secondary education, states that personalised learning pathways for learners could help them build their capabilities to obtain credits.

Kizilcec et al. [32] are concerned with low completion rate in MOOCs. Therefore, they have conducted a study to examine patterns of learners' engagement and disengagement with the MOOCs course, and consecutively they have suggested for MOOCs to offer adaptive content or assistance to learners according to their needs. Their suggestion is further supported by Martin et al. [33] who believe that learning in MOOCs can be encouraged by providing predefined personal paths and super badges that indicate the competence level of each individual learner.

On the other hand, Aoki [34] and Stine [35] focus on business model for MOOCs. While Stine [35] indicates mass personalisation can have a positive business impact to MOOCs, Aoki [34] points out that MOOCs is representing a new business model. Aoki [34] states that content providers for lectures, assessments/accreditation and tutorial supports will eventually be separately established and organised. The author presumes that the learners' data will be shared among separate organisations to enable personalisation in MOOCs.

Despite the apparent needs for personalised learning in MOOCs, Kay et al. [20], Buffat et al. [36] and Daniel et al. [37] point out that the existing MOOCs are not even half way through in implementing personalisation. Nevertheless, without personalisation, learners may reduce their participations and eventually drop out from a MOOC, which is one of the biggest concerns of MOOCs [38]. Noteworthy that even though, there is nonexistence of personalisation practice on the existing MOOCs platforms, Hollands and Tirthali [6] point out that MOOCs still present the term POOC "Personalised Open Online Course" into their full report. It is also stated that the success of MOOCs will depend on how much the learning process is personalised.

3.2 Category 2: Proposal

The literature that is considered under this category mainly involves project launches which are funded for the aim of personalising online education for masses, projects' proposals for implementing personalisation services in the existing non-personalised MOOCs, and conceptual research frameworks.

Most of the research works are driven by concerns over the inefficiency of MOOCs design, delivery, and assessments. For instance, Daradoumis et al. [39] and Bassi et al. [40] voice their concerns in several different research papers. According to the authors, as most of MOOCs courses are not learner-centric, and they provide same content for all learners, the effectiveness of the tutoring is generally poor, feedbacks are insufficient and peer-based evaluation is usually unprofessional. To address these deficiencies, the authors propose an agent-based framework for MOOCs. Agents collect data and analyse them according to several perspectives including educational goal, pedagogical preferences, time management and so forth. The analysed data is used by other agents for content customisation, tutoring feedback, system-learner alert as well as assessing and monitoring learners' learning progress in MOOCs. The authors indicate that intelligent agents could also be used for reducing fraud and cheating during online tests.

In a most recent research, Paquette et al. [41] enrich an agent-based framework with a competency-based model to generate recommendations of learning scenarios. In order to give learners recommendations, learners are grouped as novice, intermediate, and advanced in this research.

Yee-King and d'Inverno [42] is another research using agent-based model to personalise MOOC education recently in 2015. In this research, agents store the information about learners such as goals of person and current state of skills. Agents also identify learners' current state and data/content provided to find an optimal learning plan and possible human connections that might be helpful.

Brouns et al. [43] put forward a personalisation component which will be integrated to the existing EMMA platform[2]. EMMA platform is a MOOC platform delivering courses in different languages from different European Universities; therefore, learners may be overwhelmed with huge number of courses and language choices. Through this personalisation component, EMMA aims to provide personalised feedback and individualised learning paths to support learners to achieve their learning goals.

Similarly, Wilkowski et al. [44] have conducted an analysis on learners' goals and their achievements on the tested skills and activities by executing "Mapping with Google" course in MOOCs. Each learner was asked to complete a questionnaire about their learning goals to join the course and their previous experiences with the Google map. The authors then compared learners' learning goals with their behaviours in the course (i.e. watched videos, completed activities), and found out that their behaviours were very much determined by their goal. Therefore, the authors conclude that the course delivery could be personalised based on learners' goals. Their proposed system could be adapted to learner's requirements in two ways. First is to ask for learners' goals prior to delivering personalised learning pathway to each of them. Secondly, to have learners select the course elements such as some video lectures and assessments from a list for a customised course.

Leony et al. [45] focus on identifying learners' emotions in order to serve learner with personalised content. The authors propose four models for detection of frustration, confusion, boredom and happiness by using learners' activities such as how many quiz they take, how much time they spent on it, how many badget they have and so on. The authors plan to test model in a MOOC for improving learners' engagement in MOOCs.

Pham and Wang [46] consider ITS for optimising benefit from video lectures of MOOCs on a mobile device. In order to identify learners' mind wandering and heart rate, the system uses on-lens finger gestures. Even though it has not evaluated on a MOOC platform, it could be beneficial for to help instructors understand learners' progress.

De Maio et al. [47] also believe that learners' engagement with the video lecture materials in MOOCs as passive. To improve learners' engagement with MOOCs, the authors propose a methodology to support learners to navigate the fragments of one or more videos lectures so that learners could connect their goals and prior knowledge with the key concept of the lectures. The authors use taxonomy building for constructing a knowledge model for the concepts of lectures. The main idea is to enable inter-linking between different MOOCs courses and navigate learners to related ones. However, this part of the research has not been conducted.

Fasihuddin et al. [48] propose an approach for personalised learning experience in MOOCs based on learners' learning styles. The authors define the kind of material that should be included in the lecture for a particular learning style. For example, while visual learning objects should be accessible for visual learners, such

[2] http://platform.europeanmoocs.eu.

need is not a necessity for verbal learners. However, this is an ongoing research and a prototype is still not yet completed.

Elkherj and Freund [49] have developed an adaptive hint system for the undergraduate online course "Introduction to probability and Statistics" on the Webwork, which is a platform for managing homework assignments in mathematics. This course was attended by 176 students and hints were written by the tutor each time learners made a mistake or failed a test. The authors express that the need for manual labour for analysing learners' failure and writing helpful hints makes the system inconvenient for MOOCs. Therefore, they propose some possible approaches that could address this problem. The first is for students to hints to their peers. Secondly, create hint libraries. Finally, use machine-learning techniques to map students' mistakes with hints and consecutively send the most relevant hint to them.

Brouns et al. [50] propose ECO sMOOC for the EU-funded project called Elearning, Communication and Open-data: Massive Mobile, Ubiquitous and Open Learning (ECO). sMOOC refers to being a social-based MOOCs which is accessible from different types of social media and mobile devices. Learning is executed devices through content contextualisation based on learners' interactions and participations in the course using mobile and gamification approaches. The ECO sMOOC environment is described as learner-centric approach, which is adaptable to learners' intention. However, the project is in the very early stage, and any real experience with it has not yet available.

Bain et al. [51] suggest AMOOC (Accessible Open Online Course) movement to make MOOC courses more accessible for learners with disabilities. The paper focuses on delivering course content in appropriate forms for disable learners. They also mention that the system will be conducted using Adaptive Mobile Online Learning (AMOL) for adapting coursework to each learner's learning style. Similarly, Sanchez-Gordon and Lujan-Mora [52] also focus on enabling education for disabled learners. They have proposed an adaptive content presentation in MOOCs based on the disability that learners have such as blind, low vision, deaf, dyslexia.

Collet [53] proposes POEM (Personalised Open Education for the Masses) platform project for designing personalised learning management system (LMS) for massive learning. The author believes that personalisation of massive education is only possible with intelligent ICT (Information and Computing Technology) platforms. In POEM, visual and dynamic Knowledge Maps of domains for each course are constructed to provide different possible learning paths to learners. POEM will also provide inter-tutorship and automatic assessments. Apart from that, the system will ask learners to post new questions or new contents to the platform.

Bansal [54] and Birari [55] have utilised the concept of ITS for personalising learning experiences with MOOCs from different perspectives. Bansal [54] focuses on providing recommendations for learners to do additional learning activities to improve their lack of knowledge on a particular topic. In order to model learners' knowledge, the author uses the fuzzy cognitive map. On the other hand, Birari [55] models learners' cognitive state by Bayesian network so that adaptive testing and adaptive guidance can be delivered to learners.

Slightly on a different note, Fidalgo-Blanco et al. [56] has identified three weaknesses in MOOCs: high dropout rate, lack of cooperative activities among learners, and poor continuity of learning communities when a MOOCs course ends. According to the authors' definition, learning community includes activities, resources, and similar groups. To improve learning experiences in MOOCs, the authors have outlined the components of learning community that should be personalised based on learners' learning goals, previous knowledge, etc. These personalisation inputs are captured and diagnosed through initial assessments.

Similarly, Zhuhadar and Butterfield [9] point out that providing a singular curriculum to a diverse MOOCs community has caused low completion rates in MOOCs. To address this problem, the authors propose Personalised Open Collaborative Courses (POCCs) which tracks learners' attitude during the course and delivers the personalised content based on learners' activities and their prior-knowledge. In order to achieve this goal, the authors examine sub communities in MOOCs to design a personalised social recommender system.

3.3 Category 3: Implementation

Research works reported in this category provide a more concrete evidence of approaches towards implementing personalisation in MOOCs. This category considers either partly or fully implemented personalised systems that may have performed some kind of testing on either system performance or student performance. Noteworthy that majority of the systems have not yet completed their final evaluations, and the projects are still ongoing.

An algorithm of an adaptive study planner for MOOCs learners, targeted to novice learners in MOOCs is presented by Alario-Hoyos et al. [57] and Gutiérrez-Rojas et al. [58]. The adaptive planner creates a personalised study schedule for each learner based on their priority of the course, available time slot and the course requirements. Alario-Hoyos et al. present further improvement and implementation of their research in [59]. Likewise, Cordier et al. [60] develop a tracing system to help learners control their learning activities on different learning platforms.

Burgos and Corbí [61] present a rule-based technology-enhanced learning recommendation model in order to improve users' performance in MOOCs and other Open Educational Resources (OERs). The model tracks learners' performances and their interactions with the lectures. It consecutively map the related data according to the tutor's rules for recommendation such as minimum number of required activity in a lecture and minimum score on a given test. Based on the results of rules mapping, a recommendation is made. If a learner satisfies the tutor's rule to be successful, then the learner gets positive comment such as "Well done!" and gets recommendation for the subsequent tasks. Otherwise, the system gives alert feedback to the learner to request support from the online tutor and peers, and locks any further activities.

Ketamo [62] utilises ITS technologies for providing recommendations to support learners' cognitive progress and motivation in MOOCs. The content that will be provided to learners is defined as semantic network. This approach requires a learner to complete and succeed relevant test on a learning concept prior to recommending the next related learning concepts. According to the preliminary evaluation results, learners' performances were improved when using the recommendation service.

However, a considerable portion of learners was still not motivated to learn, and eventually dropped the course.

Cook et al. [7] propose a user model for MOOCs. The proposed user model tracks learners' activities such as when a learner loads a document or when a learner checks a problem. The system models learners' current situation based on defined learning objectives and intended learning outcomes along with each learner's activity on the MOOC.

Shatnawi et al. [64, 65] propose system architecture for providing personalised feedback to learners in MOOCs by using text-mining technique. Since the course creators are not able to provide timely feedback due to massive number of learners, the authors propose a method for providing automatic content related feedback by using domain ontology, machine learning, and natural language processing. When a learner writes a post, the system will determine its type, whether it is a question, a comment, or a feedback, and organised it into a suitable domain under the related topic in a repository. If a learner posts a question, the system will automatically search the repository and returns semantically relevant information or personalised feedback to the learner.

Sonwalker [66] proposes an adaptive MOOC that offers adapted learning contents based on learning styles with the concern of pedagogical effectiveness of MOOCs. The author proposes the learning cube that illustrates organisation of learning objects developed in text, graphics, audio, video, animations, and simulations according to different learning styles. In this study, learners' learning style is diagnosed via a diagnostic test as suggested by Fidalgo-Blanco et al. [56]. The performance test result is promising. Sonwalker further improve the adaptive system with the aid of cloud computing reported in [67].

Fidalgo-Blanco et al. [68] have improved their research, which is discussed in Sect. 3.2 [56], and tested with a pilot. They also aim to provide learners with adaptive content presentation based on their profile and preferences likewise [67]. Therefore, the authors build a technological framework (1) to adapt learning activities (provided by x MOOCs and cMOOCs) to learners' profile and preferences and (2) to enable knowledge management, and (3) to use learning analytics to monitor learners' cooperative works.

Yang et al. [10] design a personalised support on MOOCs discussion forums for helping learners to reach the topics in which they are interested. The authors use both collaborative and content filtering techniques to capture the most relevant forum threads. Their system performance test results show that the system performance of the proposed personalisation model is satisfactory, however, learners' satisfaction test has not yet examined.

Agrawal et al. [69] also consider the large amount of post on discussion forums in MOOCs. The system is proposed in the paper first identifies confusion that is stated in a post on discussion forum and recommends a related education video clip to the object of confusion. So that, if a learner's post is overlooked by an instructor in a pile of posts on discussion forum, the learner will receive intelligent and adaptive help to solve their confusion.

Some researchers modify existing personalised technology-enhanced learning systems for MOOCs courses. For example Miranda et al. [70]'s work aims to provide a pedagogy-based guide for items assessment based on the ontological relations between learning subjects in the lectures which are defined by the course creator. According to a learner's assessment's score, a personalised learning pathway is constructed for the learner. Similarly, Henning et al. [71] also adapt an existing technology-enhanced learning system into MOOCs. The system supports learners through personalised navigation based on their learning performances and the association between learning subjects.

4 Discussion

Result from the analysis of the needs related literature shows that the pedagogical design of MOOCs is insufficient, therefore, educational data mining should be applied to provide personalised services such as personalised learning pathways, personalised assessments, adaptive feedbacks, and recommender services. To address the needs for personalisation in MOOCs, research in category Proposals and category Implementations have proposed several outlines, frameworks, and projects' proposals, as well as prototypes for implementing personalisation and adaptation in MOOCs.

For instance, Kalz and Specht [30], Kizilcec et al. [32], and Ye et al. [17] from category Needs suggest to cluster MOOCs's learners for personalisation. The suggestion was implemented by Fidalgo-Blanco et al. [56], Fasihuddin [48], Sonwalker [66], and Paquette [41] in which they applied a diagnostic test at the beginning of the course to understand which group (i.e. learning style) a learner belongs to. However, this method is based on learners' participations in the diagnostic test, and majority of learners are not interested in doing tests. Realising this problem, Zhuhadar and Butterfield [9] have suggested using some social networking analysis (SNA) techniques to diagnose learners and automatically cluster them according to the most suited sub community in MOOCs based on their activities. Even though this method does not need learner's self-statement, a learner is required to participate in the course's lectures and activities until the system can gather sufficient information about the learner in order to determine a suitable cluster for the learner.

Another example is by the work of Shaw [6] who believes that the application of ITS technique can actualise mass personalisation in MOOCs. The belief was translated by Pham and Wang [46], Bansal [54], Bariri [55], and Ketamo [62] who implemented ITS techniques in MOOCs for personalising contents, learning pathways, and providing recommendations. Additionally, Cok et al. [63] also offers a user model for modeling learners' current state.

Note that even though Yang et al. [10] and Brouns et al. [50] did consider the social feature of MOOCs, for example they personalise online forum threads to learners based on their forum activities and peers connections, they did not build a personalised learning network in MOOCs or social network analysis for improving learning networks as suggested by Kalz and Specht [30] and Kay et al. [20]. Therefore, continuity problem of learning communities identified by Fidalgo-Blanco et al. [9] remains unsolved.

5 Conclusion

In conclusion, this literature survey has demonstrated that there is a growing trend of researchers embarking in the possibility of implementing personalisation and adaptation in MOOCs in order to improve users' engagements, hence reduce MOOCs' drop-out rate problem. 66 papers are identified as relevant to personalisation of MOOCs and deeply examined. The trend is mainly motivated by the fact that MOOCs learning has the potential to spark demands for personalised learning due to its massive and geographically dispersed learners with diverse background. In addition to that, MOOCs environment does provide the basic requirements for personalised learning such as the availability of huge learners' data, flexible learning, and learner-teacher independence. Our categorisation of the literature identified three distinct types of papers.

1. These concerned with the need or motivation for personalisation in MOOCs.
2. Outlines of plans or proposals for implementing personalisation in MOOCS.
3. Accounts and evaluations of the implementation of personalisation services in MOOC.

We found that data mining techniques are often used to exploit huge learners' data in MOOCs, and majority of the studies are concerned on the pedagogical design issues. Therefore, many researchers have proposed solutions based on personalisation and adaptation techniques such as personalised learning pathways and personalised feedback. However, there is not yet any tangible research that focuses on building personalised learning networks even though the need has been identified by Kalz and Specht [30], Kay et al. [20] and Fidalgo-Blanco et al. [56]. It is expected that this issue will gain more attention in the nearest future.

References

1. Jona, K., Naidu, S.: MOOCs: emerging research. Distance Educ. **35**(2), 141–144 (2014)
2. McAuley, A., Stewart, B., Siemens, G., Cormier, D.: The MOOC Model for Digital Practice, p. 33. University of Prince Edward Island, Charlottetown (2010)
3. Siemens, G.: Connectivism: a learning theory for the digital age. Int. J. Instr. Technol. Distance Learn. **2**(1), 3–10 (2005)
4. Daniel, J.: Making sense of MOOCs: musing in a maze of myth, paradox and possibility. J. Interact. Media Educ. **2012**(3) (2012)
5. Hollands, F.M., Tirthali, D.: MOOCs: expectations and reality. Full report, Center for Benefit-Cost Studies of Education, Teachers College Columbia University (2014). http://cbcse.org/wordpress/wp-content/uploads/2014/05/MOOCs_Expectations_and_Reality.pdf
6. Shaw, C.: Intelligent tutors and personalized education (2012). http://isites.harvard.edu/fs/docs/icb.topic1283433.files/Shaw_12_rs.pdf
7. Sunar, A.S., Abdullah, N.A., White, S., Hugh, C.D.: Personalisation of MOOCs: the state of the art. In: 7th International Conference on Computer Supported Education, CSEDU 2015, vol. 1, pp. 88–97 (2015)
8. Liyanagunawardena, T.R., Adams, A.A., Williams, S.A.: MOOCs: a systematic study of the published literature 2008–2012. Int. Rev. Res. Open Distance Learn. **14**(3), 202–227 (2013)
9. Fidalgo-Blanco, Á., García-Peñalvo, F.J., Sein-Echaluce, M.: A methodology proposal for developing adaptive cMOOC. In: 1st International Conference on Technological Ecosystem for Enhancing Multiculturality, pp. 553–558. ACM (2013)

10. Fidalgo-Blanco, Á., Sein-Echaluce, M.L., García-Peñalvo, F.J.: Methodological approach and technological framework to break the current limitations of MOOC model. J. Univ. Comput. Sci. **21**, 712–734 (2015)
11. Bartlett-Bragg, A.: The new normal: emerging trends in 2015. Training Dev. **42**(2), 17 (2015)
12. Fasimpaur, K.: Massive and open. Learn. Lead. Technol. **40**, 12–17 (2013)
13. Freeman, M., Hancock, P.: Milking MOOCs: towards the right blend in accounting education. Acad. Leadersh. Ser. **4**, 86–100 (2013)
14. Godwin-Jones, R.: Emerging technologies global reach and local practice: the promise of MOOCs. Announcements and Call for Papers, **5** (2014)
15. Harman, K., Koohang, A.: MOOC 2050: a futuristic tour. Issues Inf. Syst. **14**(2), 346–352 (2013)
16. O'Donnell, E., Lawless, S., Sharp, M., Wade, V.: A review of personalised e-learning: towards supporting learner diversity. Int. J. Distance Educ. Technol. **13**, 22–47 (2015)
17. Ye, C., Kinnebrew, J.S., Biswas, G., Evans, B.J., Fisher, D.H., Narasimham, G., Brady, K.A.: Behavior prediction in MOOCs using higher granularity temporal information. In: 2nd (2015) ACM Conference on Learning@ Scale, pp. 335–338. ACM (2015)
18. Yates, R.: Educational technologies to support new directions in teaching practice. Int. J. Inf. Educ. Technol. **3**(6), 602–606 (2013)
19. Knox, J.: From MOOCs to learning analytics: scratching the surface of the 'visual'. eLearn **2014**(11), 3 (2014)
20. Kay, J., Reimann, P., Diebold, E., Kummerfeld, B.: MOOCs: so many learners, so much potential. IEEE Intell. Syst. **28**(3), 70–77 (2013)
21. Kalz, M.: Lifelong learning and its support with new technologies. In: Smelser, N.J., Baltes, P.B. (eds.) International Encyclopaedia of the Social and Behavioral Sciences. Pergamon, Oxford (2014, in press)
22. Williams, J.J., Kim, J., Keegan, B.C.: Supporting instructors in collaborating with researchers using MOOClets. Available at SSRN 2580666 (2015)
23. Amo, D.: MOOCs: experimental approaches for quality in pedagogical and design fundamentals. In: 1st International Conference on Technological Ecosystem for Enhancing Multiculturality, pp. 219–223. ACM (2013)
24. Yousef, A.M.F., Wahid, U., Chatti, M.A., Schroeder, U., Wosnitza, M.: The effect of peer assessment rubrics on learners' satisfaction and performance within a blended MOOC environment. In: CSEDU 2015 Conference, vol. 2, pp. 148–159 (2015)
25. Sanna, R., Anne-Maria, K.: Wanted: MOOC Pedagogy. EduLearn15 (2015)
26. Huggins, S., Smith, P.: Using an 'open approach' to create a new, innovative higher education model. Open Prax. **7**(2), 153–159 (2015)
27. McLoughlin, C.E.: The pedagogy of personalised learning: exemplars, MOOCS and related learning theories. Educ. Multimedia Hypermedia Telecommun. **2013**(1), 266–270 (2013)
28. Knox, J., Ross, J., Sinclair, C., Macleod, H., Bayne, S.: MOOC feedback: pleasing all the people? In: Krause, S., Lowe, C. (eds.) Invasion of the MOOCs, vol. 98. Parlor Press, Anderson (2014)
29. Ling, J.: Research of construction plan for computer basics personalized intelligent MOOCs resources. In: 3rd International Conference on Management, Education, Information and Control (MEICI 2015), pp. 1613–1616 (2015)
30. Kalz, M., Specht, M.: If MOOCs are the answer-did we ask the right questions Implications for the design of large-scale open online courses. Maastricht School of Management in Its Series Working Papers, 2013/25 (2013)
31. Cavanaugh, J.: The coming personalization of postsecondary education competencies. CAEL 2013 Forum & News: Competency-Based Education. pp. 2–5 (2013)

32. Kizilcec, R.F., Piech, C., Schneider, E.: Deconstructing disengagement: analyzing learner subpopulations in massive open online courses. In: 3rd International Conference on Learning Analytics and Knowledge, pp. 170–179. ACM (2013)
33. Martin, S., Peire, J., Castro, M.: Proyecto WePrendo (2013). http://www.ieec.uned.es/Investigacion/archivos/informe%20WEPRENDO_DIEEC.pdf
34. Aoki, K.: Paradoxes between personalisation and massification. In: 2013 Proceedings of the International Conference on the Future of Education, 3rd edn (2013)
35. Stine, J.K.: MOOCs and executive education. In: Directors Conference (2013). http://uniconexed.org/2013/research/UNICON-Stine-Research-06-2013-final.pdf
36. Buffat, M., Mille, A., Picasso, M.: Feedbacks on MOOCS. In: ESAIM: Proceedings and Surveys, vol. 50, pp. 66–80 (2015)
37. Daniel, J., Cano, E.V., Gisbert, M.: The future of MOOCs: adaptive learning or business model? RUSC Univ. Knowl. Soc. J. **12**(1), 64–73 (2015)
38. Stevanović, N.: Effects of motivation on performance of students in MOOC. In: SINTEZA 2014 Internet and Education, pp. 418–422 (2014)
39. Daradoumis, T., Bassi, R., Xhafa, F., Caballé, S.: A review on massive eLearning (MOOC) design, delivery and assessment. In: P2P, Parallel, Grid, Cloud and Internet Computing (3PGCIC), pp. 208–213. IEEE (2013)
40. Bassi, R., Daradoumis, T., Xhafa, F., Caballé, S., Sula, A.: Software agents in large scale open eLearning: a critical component for the future of massive online courses (MOOCs). In: 6th IEEE International Conference on Intelligent Networking and Collaborative Systems, SINCOS, pp. 184–188 (2014)
41. Paquette, G., Mariño, O., Rogozan, D., Léonard, M.: Competency-based personalization for massive online learning. Smart Learn. Environ. **2**(1), 1–19 (2015)
42. Yee-King, M., d'Inverno, M.: Pedagogical agent models for massive online education. In: 1st International Workshop on AI and Feedback, AInF 2015, pp. 2–9 (2015)
43. Brouns, F., Tammets, K., Padrón-Nápoles, C.L.: How can the EMMA approach to learning analytics improve employability? (2014). http://dspace.learningnetworks.org/bitstream/1820/5542/1/submission9_M4WS.pdf
44. Wilkowski, J., Deutsch, A., Russell, D.M.: Student skill and goal achievement in the mapping with google MOOC. In: 1st ACM Conference on Learning@ Scale Conference, pp. 3–10. ACM (2014)
45. Leony, D., Muñoz-Merino, P.J., Ruipérez-Valiente, J.A., Pardo, A., Kloos, C.D.: Detection and evaluation of emotions in massive open online courses. J. Univ. Comput. Sci. **21**(5), 638–655 (2015)
46. Pham, P., Wang, J.: AttentiveLearner: improving mobile MOOC learning via implicit heart rate tracking. In: Conati, C., Heffernan, N., Mitrovic, A., Verdejo, M. (eds.) AIED 2015. LNCS, vol. 9112, pp. 367–376. Springer, Heidelberg (2015)
47. De Maio, C., Loia, V., Mangione, G.R., Orciuoli, F.: Automatic generation of SKOS taxonomies for generating topic-based user interfaces in MOOCs. In: Rensing, C., de Freitas, S., Ley, T., Muñoz-Merino, P.J. (eds.) EC-TEL 2014. LNCS, vol. 8719, pp. 398–403. Springer, Heidelberg (2014)
48. Fasihuddin, H.A., Skinner, G.D., Athauda, R.I.: Personalizing open learning environments through the adaptation to learning styles. In: ICITA 2014, 9th International Conference on Information Technology and Applications, Sydney, Australia, July 2014, ISBN: 978-0-9803267-6-5 (2014)
49. Elkherj, M., Freund, Y.: A system for sending the right hint at the right time. In: 1st ACM Conference on Learning@ Scale Conference, pp. 219–220. ACM (2014)

50. Brouns, F., Mota, J., Morgado, L., Jansen, D., Fano, S., Silva, A., Teixeira, A.: A networked learning framework for effective MOOC design: the ECO project approach. In: Teixeira, A.M., Szücs, A. (eds.) 8th EDEN Research Workshop, Challenges for Research into Open and Distance Learning: Doing Things Better: Doing Better Things, pp. 161–171, EDEN, Oxford, United Kingdom, Budapest, Hungary (2014)
51. Bain, K., Chan, B., Bates, L.: AMOOC: improving access to MOOCs using speech recognition (2013)
52. http://liberatedlearning.com/wp-content/uploads/2011/02/AMOOC_Apr_2013.pdf
53. Sánchez Gordón, S., Luján Mora, S.: Adaptive content presentation extension for open edX: enhancing MOOCs accessibility for users with disabilities. In: 8th International Conference on Advances in Computer-Human Interactions, pp. 181–183 (2015)
54. Collet, P.: POEM (Personalised Open Education for the Masses) (2013). http://blog.educpros.fr/pierredubois/files/2013/07/Financement.pdf
55. Bansal, N.: Adaptive recommendation system for MOOC. Doctoral dissertation, Indian Institute of Technology, Bombay (2013)
56. Birari, N.: Intelligent tutoring system using computerised adaptive testing and interaction logs for MOOCs. Doctoral dissertation, Indian Institute of Technology, Bombay (2014)
57. Zhuhadar, L., Butterfield, J.: Analyzing students logs in open online courses using SNA techniques. In: 20th Americas Conference on Information Systems, AMCIS 2014 (2014)
58. Alario-Hoyos, C., Leony, D., Estévez-Ayres, I., Pérez-Sanagustín, M., Gutiérrez-Rojas, I., Kloos, C.D.: Adaptive planner for facilitating the management of tasks in MOOCs. In: V Congreso Internacional sobre Calidad y Accesibilidad de la Formación Virtual, CAFVIR 2014, Antigua Guatemala, Guatemala, pp. 517–522 (2014)
59. Gutiérrez-Rojas, I., Alario-Hoyos, C., Pérez-Sanagustín, M., Leony, D., Delgado-Kloos, C.: Scaffolding self-learning in MOOCs. In: Proceedings of the 2nd MOOC European Stakeholders Summit, EMOOCs, pp. 43–49 (2014)
60. Alario-Hoyos, C., Estévez-Ayres, I., Sanagustín, M.P., Leony, D., Kloos, C.D.: MyLearningMentor: a mobile app to support learners participating in MOOCs. J. Univ. Comput. Sci. **21**(5), 735–753 (2015)
61. Cordier, A., Derbel, F., Mille, A.: Observing a web based learning activity: a knowledge oriented approach. Research report, LIRIS UMR CNRS 5205 (2015)
62. Burgos, D., Corbí, A.: A recommendation model on personalised learning to improve the user's performance and interaction in MOOCs and OERs. In: IITE 2014 International Conference, UNESCO Institute for Information Technologies in Education, Moscow, Russia, 14–15 October 2014
63. Ketamo, H.: Learning fingerprint: adaptive tutoring for MOOCs. World Conf. Educ. Multimedia Hypermedia Telecommun. **2014**(1), 2458–2467 (2014)
64. Cook, R., Kay, J., Kummerfeld, B.: MOOClm: user modelling for MOOCs. In: Ricci, F., Bontcheva, K., Conlan, O., Lawless, S. (eds.) UMAP 2015. LNCS, vol. 9146, pp. 80–91. Springer, Heidelberg (2015)
65. Shatnawi, S., Gaber, M.M., Cocea, M.: Text stream mining for massive open online courses: review and perspectives. Syst. Sci. Control Eng.: Open Access J. **2**(1), 664–676 (2014)
66. Shatnawi, S., Gaber, M.M., Cocea, M.: Automatic content related feedback for MOOCs based on course domain ontology. In: Corchado, E., Lozano, J.A., Quintián, H., Yin, H. (eds.) IDEAL 2014. LNCS, vol. 8669, pp. 27–35. Springer, Heidelberg (2014)
67. Sonwalkar, N.: The first adaptive MOOC: a case study on pedagogy framework and scalable cloud architecture—Part I. In: MOOCs Forum, vol. 1(P), pp. 22–29 (2013)

68. Sonwalkar, N.: Cloud based adaptive learning systems. White Paper (2015). http://static1.squarespace.com/static/53eb8591e4b0ba68f27eea55/t/54c65ff2e4b064f7f8ee9a07/1422286871164/CloudbasedAdaptiveWhitePaper.pdf
69. Yang, D., Piergallini, M., Howley, I., Rose, C.: Forum thread recommendation for massive open online courses. In: 7th International Conference on Educational Data Mining (2014)
70. Agrawal, A., Venkatraman, J., Leonard, S., Paepcke, A.: YouEDU: addressing confusion in MOOC discussion forums by recommending instructional video clips. In: 8th International Conference on Educational Data Mining, pp. 297–304 (2015)
71. Miranda, S., Mangione, G.R., Orciuoli, F., Gaeta, M., Loia, V.: Automatic generation of assessment objects and remedial works for MOOCs. In: Information Technology Based Higher Education and Training (ITHET), pp. 1–8. IEEE (2013)
72. Henning, P.A., Heberle, F., Streicher, A., Zielinski, A., Swertz, C., Bock, J., Zander, S.: Personalized web learning: merging open educational resources into adaptive courses for higher education. Personalization Approaches in Learning Environments, p. 55 (2014)

An Interactive Source Code Visualisation Plug-in for the MindXpres Presentation Platform

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Abstract. Nowadays, the teaching of programming concepts and algorithms is often conducted via slideware such as PowerPoint or Keynote, with the instructor going through a sequential series of slides showing static pieces of program code. As outlined in this paper, such a slideware-based approach has its limitations in terms of the authoring as well as the delivery of content for a programming course. Nevertheless, there is a rich body of research on how to best teach programming concepts and algorithms where it has been shown that this process very much depends on the mental models developed by scholars when learning how to program. Based on this existing body of research, we derived a number of requirements for an improved source code visualisation and presentation in slideware tools. We present an interactive source code visualisation plug-in for the MindXpres presentation platform, which addresses these requirements and introduces a number of innovative concepts for an interactive visualisation of source code. Based on two concrete examples showing how our solution can be used for the teaching of recursion by means of a recursion tree or to explain sorting algorithms by using animation, we illustrate the extensibility and flexibility of the presented interactive source code visualisation approach. Ultimately, the presented solution should help in reinforcing a student's mental model about a presented algorithm and improve the knowledge transfer of presentations delivered in programming courses.

Keywords: Slideware · Presentation-based teaching · Programming

1 Introduction

The teaching of programming concepts and algorithms forms a fundamental part of any Computer Science and Engineering degree. However, grasping the concepts taught in programming courses is far from trivial and has been proven to be a challenge for both students as well as teachers [2,11,16,17,20,23]. Research from the early 1980 s highlights the importance of mental models when learning how to program [22]. As defined by Mayer [22], a mental model is *"a mental*

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representation of the components and the operating rules of the system" and the completeness of this representation may vary. An incomplete representation that differs from the actual characteristics of the system results in an incomplete understanding of how the computer works and will cause the novice programmer to have difficulties in writing correct programs [21]. This is further confirmed by Milne and Rowe [24] who state that students who are not able to create a mental model of the program execution do not have the ability to comprehend what is happening to the program in memory. Hence the importance of students being able to retell the learned concepts in their own words was also first brought up by Mayer [22]. It is widely accepted that by having access to a more complete mental model of the system, the learning and practising of programming can be achieved in a more effective way [5].

Given the importance of such a mental model, it is not surprising that researchers aim to develop tools and methods in the form of visual aids for reinforcing the mental model of students [21,32]. In a procedural programming language, the program becomes a sequential process. This process is represented by various changes of states after an expression has been executed. Therefore, Mayer [22] states that a possible solution for providing an effective mental model is to use visuals and to show the user the changes in state—such as variable changes—while the program is executed. In terms of teaching methods, Jenkins [15] argues that the main role of a teacher in programming courses should be the one of a motivator. In many other areas of computing the teacher is mainly a communicator of information. However, the teaching of programming based on only presenting information such as syntax and structure in a lecture is not sufficient as it is not immediately clear how states change and there is a lack of contribution to a student's mental model.

Nevertheless, the majority of programming courses are at least partially taught via lectures accompanied by slide decks which is not in line with the research in the domain of teaching how to program that has been mentioned earlier. In fact, these slide decks often form a major part of the study material. To make matters worse, slides that have been created by slideware such as PowerPoint or Keynote are a particularly unsuitable medium for presenting source code. As argued by Tufte [35], slide decks have evolved from their physical counterparts including photographic slides or transparencies for overhead projectors and therefore also share the limitations of these physical media types. Content is presented in a strictly linear way, it is fairly static and spatially restricted by the boundaries of the physical slides. In addition to the consequences on knowledge transfer during a lecture, these tools also impose a number of issues during the authoring phase by a presenter who would like to show some source code. In programming environments, source code is usually indented and colour coded via syntax highlighting in order to improve the readability. However, when source code is copy and pasted into a presentation, this formatting is often lost and presenters are required to manually format the code. Furthermore, even simple examples of algorithms result in lengthy blocks of source code and spatial restrictions make code less understandable. Due to these spatial restrictions, the presenter is forced to spread their code examples over multiple slides. In addition, they have to jump back and forth since programming concepts such as methods, conditional statements or loops cause the program to be executed in an order that differs from how it is written down.

We introduce an approach to present source code in a way that reinforces a user's mental model and thereby helps to increase the knowledge transfer of presentations delivered in programming courses. In addition, our solution allows presenters to include source code in their presentations without the hassle usually associated with existing slideware tools. We start by discussing some related work in Sect. 2. Based on the existing body of work and some of the shortcomings of current solutions, we derive and formulate a number of requirements for a more efficient source code visualisation in presentation tools in Sect. 3. We then detail our proposed solution in Sect. 4 and present the technical details of our prototype which has been implemented as a plug-in for the MindXpres presentation platform [28,30] in Sect. 5. In Sect. 6, we describe two different use cases of the plug-in. Finally, some concluding remarks are provided in Sect. 7.

2 Related Work

In the context of presentation tools, there exists little to no academic work trying to improve upon the issues associated with the presentation and visualisation of source code. At authoring time, one can see that state-of-the-art presentation tools do not make any effort to support the authoring and integration of source code. As mentioned before, the indentation and syntax highlighting of source code is lost when copy and pasting from the programming environment to a presentation tool like PowerPoint. Common workarounds include the use of command line tools such as pygmentize[1] or web-based tools like ToHTML[2] in order to convert source code to a representation that preserves the formatting when copy and pasting (e.g. HTML or RTF). Another popular workaround is to simply take a screenshot of the source code in the development environment and to include it in the presentation. However, the inclusion of a screenshot often results in blurry or pixelated text. While these approaches address the issue of manual formatting, they remain tedious and often suboptimal workarounds.

When broadening our view beyond the domain of presentations, we can find research that builds on the principles outlined in the previous section. In all cases these are stand-alone desktop applications that use visualisations to help users build a mental model of a program. One of the earliest tools is the Bradman tool [32] for the C programming language. It mainly relies on showing state changes after the execution of each line of code and an evaluation of the tool revealed an improved understanding of the code by its users [33]. Another solution is the VIP tool [37] for a subset of the object-oriented C++ programming language. While the VIP tool also focusses on visualising state changes, it distinguishes itself by making the concept of pointers and references—which is

[1] http://pygments.org/docs/cmdline/.
[2] http://tohtml.com.

considered to be a difficult concept to grasp for students—more understandable. Jeliot 3 [26] is a tool for visualising the object-oriented Java language. Given the nature of Java, the tool also visualises the objects and their relationships in an UML-like notation in addition to state changes while the program is executed. However, an evaluation of Jeliot highlighted that the animations were hard to interpret and apply for students, making the evaluation inconclusive [25]. Another notable feature of Jeliot is the extensible visualisation mechanism, allowing potential new third-party visualisations to be added at a later stage.

The notional machine [3] is another recent tool for visualising Java programs which bases itself on the work of Boulay [4]. While being similar to Jeliot, the notional machine intentionally limits the stepping granularity for state changes to the level of method invocations and method returns rather than to single statements. Additionally, the notional machine also allows methods to be invoked interactively (on demand) in contrast to the other tools where the execution is only possible in the order of the logical execution flow. Similarly, UUhistle [34] also offers an interactive coding mode for the Python programming language, adapting the visualisations in real-time as the user makes changes to the source code. Also jGRASP [6] defines itself as an application for understanding a program through visualisation while the user is writing the code. Finally, there is a category of tools that focusses on a specific aspect of program execution. For instance, RGraph [31] is a solution that generates a static visualisation of recursion graphs for Java programs in order to help students with the understanding of recursion. Note that we intentionally limited ourselves to the tools built for supporting students during the learning process. There are plenty of commercial products that visualise code characteristics such as the amount of lines or dependencies, performance metrics or editing history, but these solutions serve an entirely different purpose than the aforementioned tools.

In conclusion, projects such as CodeWitz [19] show that there is a clear need for better teaching tools in computer science. However, in the context of presentations, presenters are often limited to two choices. Either they have to work around the limitations of existing slideware tools or they have to use one of the standalone applications mentioned above, switching between their presentation and the external application on demand. Besides not being beneficial for the flow of the presentation, most of the standalone tools only focus on a very specific aspect of programming (e.g. recursion or memory management) and are made for a specific programming language. This implies that a programming course may require more than one of these tools to illustrate all relevant concepts or that a tool for the programming language used in the course might not even exist.

3 Requirements

Based on a detailed analysis of the related work presented in the previous section, we derived a number of requirements for more efficient source code visualisation in presentation tools. While these requirements overlap with the requirements for stand-alone desktop tools, the use in the context of a lecture requires some further thought. For instance, the typical traditional lecture mainly consists of a unidirectional flow of information since students are not as involved as, for example, in lab sessions.

R1: Automatic Indentation and Syntax Highlighting. A first step towards making source code understandable is to make it more readable. Indentation and syntax highlighting are well-established methods to improve the readability of source code as they help to interpret scope and syntactic structures. Additionally, the indentation and syntax highlighting of source code in a presentation makes the code similar to what students are used to in their programming environments. However, in contrast to existing practices in presentation tools, the formatting of code should not be a burden to the presenter and should be done automatically by the presentation tool.

R2: Efficient Navigation of Source Code. When explaining the working of a piece of source code, it is necessary to display the code as part of a presentation. However, even simple programs consist of more lines of code than would fit on a single slide. Additionally, programs rarely execute sequentially and may jump back and forth between different pieces of code, not necessarily in the order in which they were written. This forces presenters to jump back and forth between slides making it difficult for both the audience as well as the presenter to follow the program flow.

R3: Visualise the Working of the Code. From related work we learn that the mental model of a program can be built much easier when accompanied by visual aids. In addition to showing the code of the program, the tool might for instance display state changes or illustrate concepts such as pointers or recursion in order to make it clearer what is actually happening when the program executes. The idea of visualising source code in a dynamic way is supported by recent studies showing that the use of dynamic media brings measurable improvements in knowledge transfer over the use of static media [13].

R4: Integration in Presentation Tools. As slide decks are often used during lectures, it makes sense to integrate the interactive visualisations directly into our presentation rather than relying on a stand-alone application. If the interactive source code visualisation is not integrated into the presentation tool, the presenter is forced to switch between applications which takes time and breaks the flow of the presentation.

R5: Extensible Support for Multiple Languages. Even though there are a few more commonly used programming languages in the list of all existing languages, there is no consensus on what language to teach in introductory programming courses [8,12]. While each of the stand-alone tools presented in Sect. 2 only focusses on a single language, we believe that a tool for use in presentations should be able to deal with more than one language. By supporting only a single language, the tool would automatically be excluded from being used in the larger share of lectures that use other languages. Additionally, we claim that the set of supported programming languages should be extensible by third parties instead of limiting ourselves to a fixed set of languages.

R6: Extensible Visualisation Choices. It has been shown that graphical representations of programming concepts have an important role in the construction of a mental model [10,36]. However, different visualisations are needed for different scenarios. Not only do programming languages have different characteristics (e.g. object-oriented versus procedural) but also the topic may influence the type of visualisations required for the program. Related work shows that customised visualisations help with the teaching of specific concepts such as memory pointers or recursion [7]. It therefore makes sense to allow the presenter to select the desired visualisation apart from just showing some source code. Additionally, it should be possible that the pool of visualisations can be extended, especially when considering the previous requirement R5.

R7: Interactive Program Execution. Next to visualising a program, the execution might also be made more interactive and controllable by the presenter. For instance, the presenter might want to show how the same program reacts to different kinds of input, or they may wish to execute different parts of the program based on different scenarios or feedback from the students.

4 Towards Interactive Source Code Visualisation

Based on the requirements presented in the previous section, we now introduce our approach towards presenting source code in a more accessible and efficient way. In order to fulfil requirement R4, it is obvious that our solution should integrate into an existing presentation tool. As the most basic feature, the presenter should be able to include any piece of source code in a presentation and the tool should present it in a readable manner. From a technological standpoint there is no reason why a presentation tool could not automatically handle formatting issues such as indentation and syntax highlighting. A user can either explicitly specify the language or simple techniques such as Bayesian filters can be applied to automatically detect the programming language of a piece of source code. Since a programming language's syntax is formally defined, the parsing and syntax highlighting is hardly a challenge. Nevertheless, to the frustration of many presenters this simple feature is not present in current presentation tools and should therefore be provided by our tool as demanded by requirement R1. In order to break free of spatial restrictions, we suggest that source code should be scrollable if it does not fit on a single slide rather than presenting isolated chunks of code spread across slides. This allows the presenter to illustrate source code more coherently as it is easier for audience members to grasp the bigger picture. Making the code scrollable contributes to the navigation of the source code and therefore also addresses requirement R2.

While these aesthetic improvements enhance knowledge transfer, related work indicates that the visualisation of program execution may be one of the most important techniques to help students in building a mental model of a program. Therefore, our solution should not only display the static source code but one should also be able to step through the execution of the program in forward or backward order. This does not only help in illustrating the program flow, but also state changes can be shown simultaneously to highlight how each line of code influences the state of the program as described in requirement R3. Since the presenter does not always want to step through the program execution from the very beginning to the end, it also makes sense to provide a means of manually jumping to the relevant parts of the source code.

In order to fulfil requirement R5, an interactive source code visualisation solution should not limit itself to a single programming language. The tool should be able to handle different programming languages and the resulting code visualisation and execution should work in the same way, regardless of the language. However, the execution and interpretation of programs is language dependant and therefore it is impossible to offer a generic implementation that is guaranteed to work for all programming languages. We address this challenge by offering modular language support. Language-specific functionality should be bundled together as a module with a predefined interface so that the tool can select the corresponding module based on the detected language. The language-specific module is then responsible for interpreting the execution of the program and translating it to a generic representation that is understood by the visualiser. This way, the tool can support a wide variety of programming languages regardless of technical differences and even allows the set of supported languages to be extended by third parties.

Finally, in addition to the visualisation of the source code and state changes, we deem it meaningful to provide some further optional graphical visualisation. As discussed in Sect. 2, different visualisations have been developed to provide a better understanding of concepts such as memory pointers or recursion. These extra visualisations should also be implemented as interchangeable modules in order that they can be extended. They can make use of the generic execution representation provided by the language-specific modules and are thus language independent. The visualisation module gets the execution data such as state changes and method invocations in a common format and does not have to deal with language-specific details. Note that this also means that visualisation modules can be reused for different languages since, for example, recursion is a concept available in many languages.

A mock-up of our proposed solution is shown in Fig. 1. Based on the real estate available on a slide, the left half of the slide is dedicated to the visualisation of the source code. Note that the source code is properly indented, syntax highlighted and scrollable if necessary. The slider below the code allows the presenter to quickly move to a particular point in the execution and the buttons underneath allow them to go through the code one step at a time, either forwards or backwards. The right-hand side is dedicated to visualisations that adapt as the presenter steps through the code. The upper right part shows the

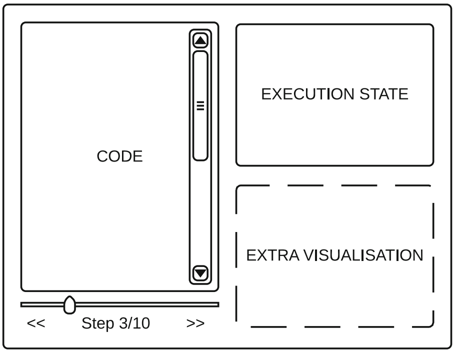

Fig. 1. Source code visualisation mock-up.

state of relevant variables whereas the lower right part can optionally be used for context-specific visualisations.

While the goal is that our tool should do as much as possible automatically, there are also cases where a presenter might want to configure the tool beforehand. For instance, in larger programs it makes no sense to visualise the changes of every single variable. In these cases, the presenter may choose to select those variables that contribute to the understanding of a program and the rest will not be displayed. The presenter might also want the execution to start at a specific point instead of having to manually find the right spot they want to discuss. Furthermore, the presenter may choose which additional visualisation to use or decide to not show any additional visualisation at all and use the full width of the slide for displaying the source code.

5 Implementation

We now present our implementation of the concepts discussed in the previous section. Before describing the technical details of our prototype implementation, we outline the overall architecture of our interactive source code visualisation solution for the MindXpres presentation platform.

5.1 Architecture

As briefly mentioned in Sect. 4, special measures need to be taken to support multiple programming languages. The main reason is that in order to fulfil requirement R3, we need to execute or interpret the provided source code to extract events, such as state changes or method invocations. Unfortunately, this process is different for each programming language which makes it impossible to provide an all-in-one solution. As detailed earlier, we bundle language-specific functionality in interchangeable modules making it possible to add new languages.

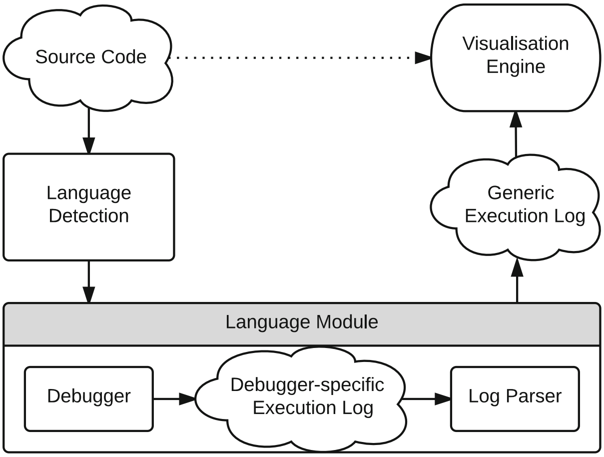

Fig. 2. Architecture for extensible language support.

The architecture chosen to support this extensibility for new programming languages is shown in Fig. 2. When source code is given to our tool by the presenter, the language can automatically be detected. In our implementation we used a Naive Bayes classifier to infer the language. This technique works particularly well for this purpose since each programming language's syntax consists of some reserved keywords (e.g. `new` or `import`) that are either unique to the language or drastically reduce the amount of potential candidates. When the code has been analysed the tool then searches its collection of language modules for the detected language. In the case that no matching module is found, the tool limits itself to just displaying the source code without any additional interactive features. However, if a matching module is found, it is passed the source code. The language module is then responsible for extracting the relevant information from the running program and for translating it to a generic representation that is understood by the visualisation engine. One of the benefits of isolating language-specific features is that the modules can make use of existing applications and libraries instead of having to implement everything from scratch. For example, we found existing debuggers to be particularly useful. A debugger is a tool that examines a running application and offers functionality to provide insights about the program flow and for finding unwanted behaviour in the form of bugs. Debuggers are hard to use and they make no real effort to reinforce a mental model [32], but their output, a so-called execution trace, can be turned into something more meaningful by our tool. Nevertheless, debuggers are standalone applications dedicated to one specific language only and different debuggers produce output in different formats. Therefore, when the language module invokes the debugger and gets an execution trace, it also translates the resulting trace into a generic format ensuring that the output of each language module has the same format. This generic execution log is then transferred to the visualisation engine together with the original source code in order that the visualisation engine can display the source code and provide additional interactive functionality such as the visualisation of state changes while the presenter steps through a piece of source code. Since the visualisation engine works with the generic execution log it does not need to have knowledge about the original language which implies that visualisations can be reused for different languages.

5.2 Generic Execution Log

As explained before, the generic execution log is the key to supporting multiple languages in an extensible manner. We have chosen the JavaScript Object Notation (JSON), a lightweight data interchange format for representing the execution log. For each programming language, a language module translates the language-specific execution log into this JSON-based representation. This means that the visualisation tool only needs to be able to process the generated JSON format and does not need to be aware about the specifics of a particular programming language.

```
int sum = 0;
for(int i = 0; i < 2; i++){
    sum = add(sum, i);
}
```

Listing 1.1. A small C program.

From the language-specific execution logs, the language module needs to extract events such as variable definitions, variable state changes as well as function invocations. For example, Listing 1.2 shows the JSON output resulting from the execution of the small C program shown in Listing 1.1.

```
[ {"line": 1, "type": "VarDefinition",
   "details": {"name": "sum",
               "value": "0"}},
  {"line": 2, "type": "VarDefinition",
   "details": {"name": "i",
               "value": "0"}},
  {"line": 3, "type": "FunctionCall",
   "details": {"name": "add"}},
  {"line": 3, "type": "StateChange",
   "details": {"name": "sum", "old": "0"
               , "new": "0"}},
  {"line": 2, "type": "StateChange",
   "details": {"name": "i", "old": "0"
               , "new": "1"}},
  {"line": 3, "type": "FunctionCall",
   "details": {"name": "add"}},
  ...
```

Listing 1.2. Generic execution log (in JSON) for Listing 1.1.

The C programming language is a purely procedural programming language but in order to support object-oriented languages the details specific to objects can also be expressed in the generic log format. This includes, for instance, method invocations and changes to object fields. While we could have used the same representation as for function invocations and variable changes, there are languages such as C++ that can have both functions and methods and therefore a separate representation is needed. Listing 1.4 shows the JSON execution log generated for the Java program illustrated in Listing 1.3.

```java
Person person = new Person("John");
person.setAge(19);
```

Listing 1.3. A small Java program.

```json
[
  {"line": 1, "type": "VarDefinition",
   "details": {"name": "person",
   "initialValue": "null"}},
  {"line": 1, "type": "Constructor",
   "details": {"class": "Person"}},
  {"line": 1, "type": "StateChange",
   "details": {"name": "person",
   "old": "null", "new": "Person"}},
  {"line": 2, "type": "MethodCall",
   "details": {"name": "setAge",
               "object": "person"}},
  {"line": 2, "type": "ObjStateChange",
   "details": {"name": "person.age",
   "old": "0", "new": "19"}}
];
```

Listing 1.4. Generic execution log (in JSON) for Listing 1.3.

Note that a specific line of code may need multiple entries in the execution log. For instance, a line of code may define a new variable, invoke a method and use the returned value to set its state. Even though they all occur on the same line of code, the execution log should contain separate entries for each of these events. The visualisation tool may combine them into a single step for the visualisation, but at least it has access to the finer details in case certain visualisation plug-ins should need them.

5.3 MindXpres Source Code Plug-in

Our interactive source code visualisation prototype has been implemented as a plug-in for the MindXpres presentation platform [27,30]. MindXpres has been developed to overcome the limited extensibility of well-known slideware tools such as PowerPoint or Keynote and to offer a rapid prototyping platform for novel presentation ideas. The motivation behind this is that although PowerPoint offers an application programming interface (API) for creating extensions, it still enforces the usage of linear sequences of slides with relatively static content. Therefore it is often not possible to extend PowerPoint with radically new functionality. The highly modular MindXpres architecture allows any component to be replaced and new components and functionality can easily be added. For instance, users may choose to use a plug-in that visualises content using a zoomable user interface (ZUI) or they can use a plug-in that visualises the same content in a classic linear fashion as known from existing slideware. The core MindXpres engine provides various abstractions, which allows plug-in creators to focus on their innovative ideas instead of having to reimplement the basic functionality every time. For instance, the graphics engine provides functionality related to the visualisation of content with features such as the ZUI and interactive rich media visualisation plug-ins. The communication engine allows instances of a MindXpres presentation to form networks which allows plug-ins to communicate across devices and enables plug-ins for various audience-driven functionality such as polls, quizzes or screen mirroring [29].

```xml
<presentation>
  <slide title="Fibonacci Numbers">
    <bulletlist>
      <item>Fn = Fn-1 + Fn-2</item>
      ...
    </bulletlist>
    <image source="fib.jpg"/>
  </slide>
  <slide title="Fibonacci Implemented Recursively">
     <code>
        int fibonacci(int n)
        {
          if (n == 0)
            return 0;
          else if (n == 1)
            return 1;
          else {
            return fibonacci(n-1) + fibonacci(n-2);
          }
        }
     </code>
  </slide>
  <slide title="Fibonacci - Iterative">
     <code source="fib_it.c"></code>
  </slide>
</presentation>
```

Listing 1.5. MindXpres presentation in XML.

Furthermore, the communication engine allows the easy integration of hardware such as clickers, digital pens or gesture capturing devices (e.g. Leap Motion[3]) and is also able to direct the stream of captured events to other relevant MindXpres instances.

MindXpres uses HTML5 and related technologies for enhanced portability and plug-ins are written entirely in JavaScript. Although a graphical editor is under development, MindXpres presentations are currently defined in a XML-like declarative language similar to the LaTeX language used for text documents. The reasoning behind this is also similar; let the user focus on content and let the tool worry about the layout and styling. While MindXpres comes with a default set of plug-ins for basic components such as images, bullet lists, videos or slides, it is easily possible to add new plug-ins for new content types. Plug-ins also extend the vocabulary used in the MindXpres document format. More specifically, a plug-in can add new XML tags for usage in the document format.

[3] https://www.leapmotion.com.

A plug-in that introduces new tags then also takes responsibility for visualising content placed within these tags.

We have realised our proposed interactive source code visualisation approach by creating a code visualisation plug-in for MindXpres that introduces the `code` tag to the vocabulary. The plug-in provides two ways to include source code in a presentation document. Either the presenter uses an attribute of the `code` tag to refer to an external file containing source code, or the presenter just pastes the code between `code` tags. Listing 1.5 shows a shortened snippet of a MindXpres presentation that uses both ways to include source code and the resulting presentation can be seen in Fig. 3.

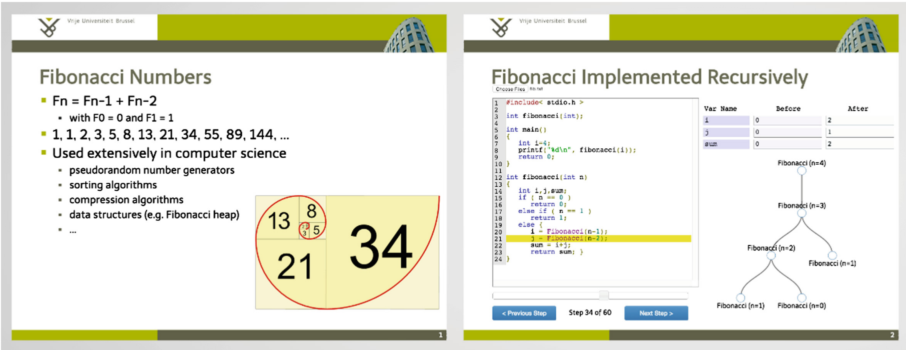

Fig. 3. A MindXpres presentation with the embedded source code plug-in.

When the MindXpres document format is compiled into a portable presentation, a MindXpres plug-in can be invoked if it contains compile-time triggers for the content that it is responsible for. In this case, the code plug-in will use a compile-time trigger to be notified when source code is encountered in the presentation. The plug-in will then detect the language and let the correct language module generate the generic execution log. This means that the corresponding language module is only invoked once, namely at compile time. The resulting log is then bundled in the presentation together with the code plug-in that is going to perform the run-time visualisation when the final presentation is opened for viewing. Because MindXpres plug-ins are written in JavaScript, we are free to use some of the powerful existing libraries offering relevant functionality. For code formatting and syntax highlighting we use Google's prettify[4] library. Furthermore, the plug-in uses the D3[5] visualisation library for some of its optional visualisations. For this prototype implementation we have implemented two language modules, namely one for C and one for Java. For the creation of the

[4] https://code.google.com/p/google-code-prettify/.
[5] http://d3js.org.

execution traces, the C module uses the GDB[6] debugger while the Java version uses JDB, a debugger included with the Java Development Kit[7].

Creating a language module requires some programming but the provided abstractions make the process fairly straightforward. The language module itself is implemented as a folder containing at least two files. A manifest file provides some metadata and specifies the programming language the module can process. The second file contains JavaScript code that implements a single method which accepts source code as input and returns a generic execution log. This code is executed if the source code plug-in detects that the presentation contains source code that was written in the programming language mentioned in the manifest file. Because the MindXpres compiler is based on Node.js, the JavaScript code can make use of existing libraries and even binaries placed alongside the two required files. In most cases, it is sufficient for a language module to include an existing debugger, have it create an execution log and translate this log into the generic execution format. However, note that there are alternative ways how a language module might obtain an execution log. For instance, a language module could also directly implement a basic interpreter in JavaScript and generate the generic execution log without the use of external tools.

6 Technical Evaluation

After describing the implementation in the previous section, we now detail two different use cases of the source code visualisation plug-in. As part of the initial prototype, we implemented two extra visualisations. A first visualisation is used to display the recursion tree when executing a recursive algorithm. The other visualisation uses animation to show how a list of numbers is processed during the execution of a sorting algorithm. Note that both visualisations can be used for any of the supported languages.

6.1 Teaching Recursion by Means of a Recursion Tree

Recursion is an important but far from trivial programming concept. However, it has previously been shown that visualisations can be beneficial when teaching recursion [7]. For this reason, we have chosen to develop a recursion visualisation as part of our technical evaluation. A common application of recursion in programming is to make a method or function call itself, possibly multiple times, to compute a smaller part of the task that it was given. One of the standard examples to illustrate this is the recursive implementation for calculating the Fibonacci sequence. In the Fibonacci sequence each number is the sum of the previous two numbers ($Fib(n) = Fib(n-1) + Fib(n-2)$). In other words, to calculate the nth number in the sequence we need to know the numbers at position $n-1$ and $n-2$, with the base case $Fib(0) = 0$ and $Fib(1) = 1$. This translates

6 http://www.gnu.org/software/gdb/.
7 https://www.oracle.com/java/.

particularly well to most programming languages as it can be implemented as a function that calls itself to calculate the previous two numbers, just like the mathematical definition.

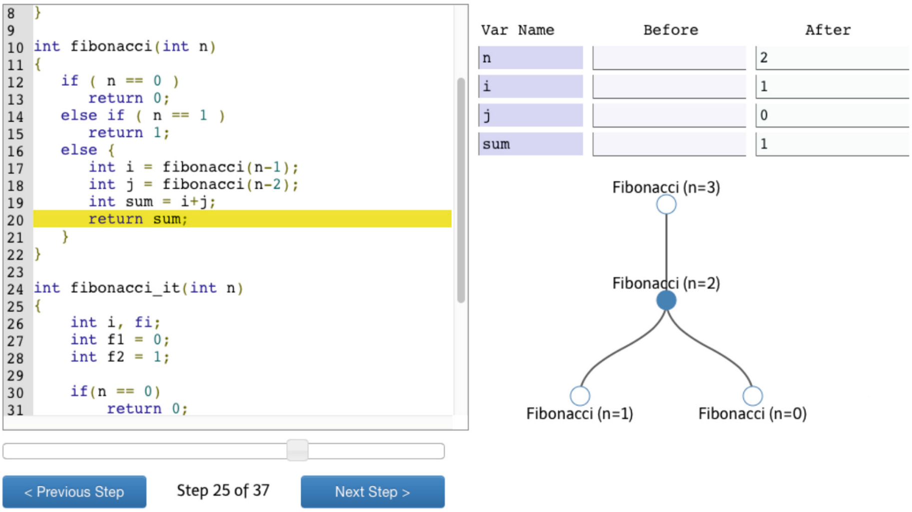

Fig. 4. MindXpres source code plug-in with recursion tree.

Figure 4 shows the MindXpres source code plug-in in action for an implementation of the Fibonacci function in the C programming language. The highlighted line indicates what line of code is being executed in the current step. As mentioned before, the buttons can be used to go forwards or backwards in the execution and the presenter may also use the slider to jump to a particular point of interest. On the right-hand side the state changes for the variables `n`, `i`, `j` and `sum` are shown. This includes their old value (`Before`) and the new value (`After`) that was assigned to them at that point of execution. The recursion tree shows a history of recursive function calls up to that point making it clearer what has happened in the previous steps. The blue dot indicates which Fibonacci number we are currently calculating. In this case, the reader can see that the program started with $Fib(3)$, but to get the result it had to calculate $Fib(2)$ and $Fib(1)$. The blue dot shows that it is currently finishing the calculation of $Fib(2)$. The tree also makes it clear that in order to calculate $Fib(2)$ it first had to calculate $Fib(1)$ and $Fib(0)$ and the results were stored in the variables `i` and `j` respectively. Hence the variable `sum`, in this case the result of $Fib(2)$, equals 1. As the recursion is performed in depth-first order and is currently backtracking, a new branch is about to be added under the top node for the calculation of $Fib(1)$. Its result will be added to the result of the left branch to form the third Fibonacci number.

While the example in Fig. 4 shows purely procedural code, the same visualisation can be used for object-oriented code. For instance, the execution of the code presented in Listing 1.3 would first show a state change in the variable `person`, from `null` (not initialised) to a new instance of a `Person`. The second line would then result in a state change in `person.age` from 0 to 19. Similarly, a recursion tree could be built based on method calls instead of function calls.

6.2 Teaching Sorting Algorithms by Using Animation

In addition to recursion, the visualisation of sorting algorithms also has been proven to be beneficial when teaching [1,9]. While changes in arrays can be shown in the upper right section dedicated to state changes, we implemented a second extra visualisation to show array manipulations more clearly by making use of colours, arrows and animation.

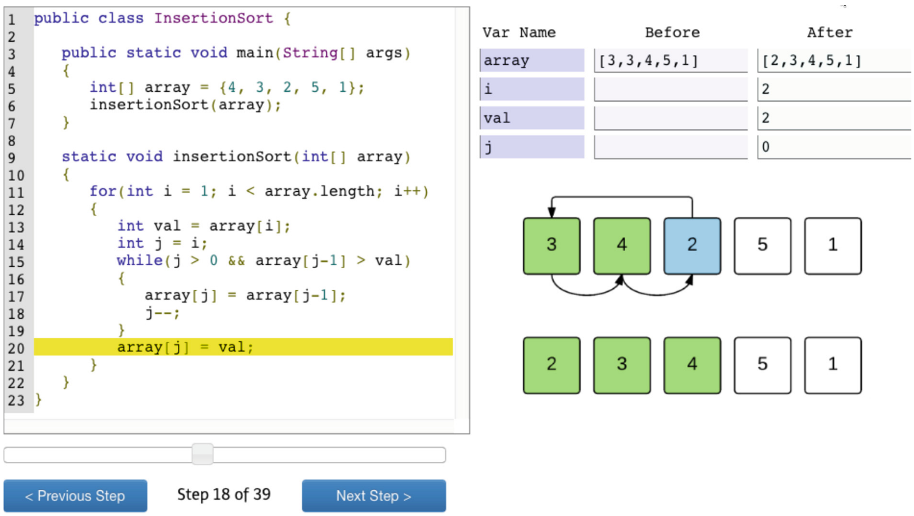

Fig. 5. MindXpres source code plug-in with array visualisation.

In Fig. 5, an implementation of the well-known insertion sort [18] sorting algorithm is shown. In short, the insertion sort works by maintaining a sorted subarray on the left side and adds new elements one by one while keeping the subarray sorted. As the presenter steps through the code, the manipulation of the array is visualised. The visualisation shows both the current state of the array as well as the changes that lead to that current state (shown above the current state). The green elements represent the part of the array that is already sorted. To give an example, Fig. 5 shows us the step where the number 2 has been added to the sorted part. In order to have space to insert the number 2, the numbers 3 and 4 had to be moved to the right as indicated by the arrows. Note that the arrows visualise multiple steps leading up to the insertion of the number 2. In this case, our extra visualisation was configured to accumulate steps until the variable `i` changes its state.

7 Discussion and Conclusion

We have introduced an interactive source code visualisation plug-in for the MindXpres presentation platform. Apart from the two discussed examples for the teaching of recursion by means of a recursion tree and the explanation of sorting algorithms by using animation, the presented solution serves as a framework for additional future source code visualisations. It further enables the experimentation with alternative innovative forms for teaching programming concepts and algorithms based on more interactive presentations. While we currently realised two language modules for the C and Java programming languages, with minimal effort it is possible to add support for additional programming languages. The presented interactive source code visualisation plug-in currently focuses on some major imperative and object-oriented programming languages. However, with further investigation of new visualisations, also non-imperative programming languages can be supported in a future version of the interactive MindXpres source code visualisation plug-in. For example, most of the presented execution state and extra visualisation would not be useful for functional programming languages such as Haskell which avoid state changes and mutable data. The presented approach for navigating source code is also not appropriate for source code that has been written in a declarative programming language (e.g. Prolog), since these programs consists of rules that are queried and triggered rather than a number of sequentially executed instructions. While the presented interactive source code visualisation does currently not support these alternative programming paradigms, in the future we might investigate how alternative visualisations can help students in enhancing their mental model for functional or declarative programming languages.

The presented source code visualisation is already an improvement when discussing larger pieces of source code since an instructor can scroll through the source code and no longer has to spread source code over multiple slides. Nevertheless, the navigation could be further improved by analysing the source code in order to add some enhancements. When the presenter, for example, clicks on a function or method call, an enhanced version of the interactive source code visualisation plug-in might jump to the function or method definition as known from most existing integrated development environments (IDEs). A limitation of the presented solution is that a presenter can only step through the source code as it has been included in the presentation with no possibility to modify the source code while delivering a presentation. In the future, we would therefore like to make the execution of programs more interactive and, for instance, allow the presenter to execute the same algorithm multiple times but with different start parameters in order to illustrate the effect of varying parameters. Furthermore, the functionality of the presented solution could be further enhanced by offering the presenter the possibility to modify values at any point during the execution and visualisation of an algorithm.

While we presented our solution mainly from the perspective of the presenter, the MindXpres presentation platform provides a number of abstractions for implementing features that are commonly found in audience response and classroom systems [29]. As discussed by Hundhausen et al. [14], the effectiveness of the visualisation of algorithms can be further increased by involving the students more closely through active learning. While a MindXpres presentation with our source code visualisation can already be used as interactive study material after the lecture, the next step would be to also include the audience during the lecture. Students might be given the chance to interactively navigate through the source code and it would no longer be the sole responsibility of the teacher to control the navigation. Of course such a collaborative source code navigation tool might also be beneficial in exercise session where students would have to reason over a presented program in some form of group work.

The technical side of the proposed extensible architecture has been evaluated by implementing two different language modules for the C as well as Java programming languages. While parts of the presented functionality of our interactive source code visualisation solution is based on earlier research in the domain of how to best teach programming concepts, in the future we also plan to do a user evaluation of the discussed interactive source code visualisation plug-in for MindXpres. When having a look at the teaching material from various universities from all around the world, one can identify that many teachers of programming courses still use traditional slideware solutions with source code that is often spread over multiple slides. Our solution can be seen as a step towards enhancing the omnipresent presentation-based teaching of programming by providing better tools for the authoring of source code slides as well as for the interactive presentation of code examples. Finally, we hope that our new way of presenting source code in a more interactive manner might inspire other researchers to also investigate new forms of presentation-based teaching solutions for programming concepts and algorithms that go beyond simply showing a set of slides with pieces of static source code.

References

1. Baecker, R.M.: Sorting out sorting: a case study of software visualization for teaching computer science, chap. 24, pp. 369–381. MIT Press (1998)
2. Bennedsen, J., Caspersen, M.E.: Failure rates in introductory programming. ACM SIGCSE Bull. **39**(2), 32–36 (2007)
3. Berry, M., Kölling, M.: The design and implementation of a notional machine for teaching introductory programming. In: WiPSE 2013, 8th Workshop in Primary and Secondary Computing Education, pp. 25–28. ACM (2013)
4. Boulay, B.D.: Some difficulties of learning to program. J. Educ. Comput. Res. **2**(1), 57–73 (1986)
5. Cañas, J.J., Bajo, M.T., Gonzalvo, P.: Mental models and computer programming. Int. J. Hum.-Comput. Stud. **40**(5), 795–811 (1994)
6. Cross II, J.H., Hendrix, T.D.: jGRASP: an integrated development environment with visualizations for teaching Java in CS1, CS2, and beyond. J. Comput. Sci. Coll. **23**(1), 5–7 (2007)
7. Dann, W., Cooper, S., Pausch, R.: Using visualization to teach novices recursion. ACM SIGCSE Bull. **33**, 109–112 (2001). ACM

8. Dewar, R.B., Schonberg, E.: Computer science education: where are the software engineers of tomorrow? Crosstalk: J. Defense Softw. Eng. **21**(1), 28–30 (2008)
9. Furcy, D., Naps, T., Wentworth, J.: Sorting out sorting: the sequel. In: ITiCSE 2008, 13th Annual Conference on Innovation and Technology in Computer Science Education, pp. 174–178. ACM (2008)
10. George, C.E.: Experiences with novices: the importance of graphical representations in supporting mental models. In: PPIG 2012, 12th Annual Workshop of the Psychology of Programming Interest Group, pp. 33–44 (2000)
11. Gomes, A., Mendes, A.J.: Learning to program - difficulties and solutions. In: ICEE 2007, International Conference on Engineering Education, pp. 53–58 (2007)
12. Guo, P.: Python is now the most popular introductory teaching language at top U.S. universities. BLOG@CACM, 7 July 2014
13. Holzinger, A., Kickmeier-Rust, M.D., Albert, D.: Dynamic media in computer science education; content complexity and learning performance: is less more? Educ. Technol. Soc. **11**(1), 279–290 (2008)
14. Hundhausen, C.D., Douglas, S.A., Stasko, J.T.: A meta-study of algorithm visualization effectiveness. J. Vis. Lang. Comput. **13**(3), 259–290 (2002)
15. Jenkins, T.: Teaching programming - a journey from teacher to motivator. In: LTSN-ICS 2001, 2nd Annual Conference of the LSTN Center for Information and Computer Science (2001)
16. Jenkins, T.: The motivation of students of programming. ACM SIGCSE Bull. **33**(3), 53–56 (2001)
17. Jenkins, T.: On the difficulty of learning to program. In: LTSN-ICS 2002, 3rd Annual Conference of the LTSN Centre for Information and Computer Sciences, vol. 4, pp. 53–58 (2002)
18. Knuth, D.E.: The Art of Computer Programming. Sorting and Searching, vol. 3, 2nd edn. Addison Wesley Longman Publishing Co., Inc, Redwood City (1998)
19. Kujansuu, E., Tapio, T.: Codewitz - an international project for better programming skills. In: EdMedia 2004, World Conference on Educational Media and Technology, pp. 2237–2239. AACE (2004)
20. Lahtinen, E., Ala-Mutka, K., Järvinen, H.M.: A study of the difficulties of novice programmers. ACM SIGCSE Bull. **37**(3), 14–18 (2005)
21. Ma, L., Ferguson, J., Roper, M., Wood, M.: Improving the viability of mental models held by novice programmers. In: ECOOP 2007, 11th Workshop on Pedagogies and Tools for the Teaching and Learning of Object Oriented Concepts. Springer (2007)
22. Mayer, R.E.: The psychology of how novices learn computer programming. ACM Comput. Surv. (CSUR) **13**(1), 121–141 (1981)
23. McCracken, M., Almstrum, V., Diaz, D., Guzdial, M., Hagan, D., Kolikant, Y.B.D., Laxer, C., Thomas, L., Utting, I., Wilusz, T.: A Multi-national, multi-institutional study of assessment of programming skills of first-year CS students. In: ITiCSE-WGR 2001, Working Group Reports from ITiCSE on Innovation and Technology in Computer Science Education, pp. 125–180. ACM (2001)
24. Milne, I., Rowe, G.: Difficulties in learning and teaching programming - views of students and tutors. Educ. Inf. Technol. **7**(1), 55–66 (2002)
25. Moreno, A., Joy, M.S.: Jeliot 3 in a demanding educational setting. Electron. Notes Theor. Comput. Sci. **178**, 51–59 (2007)
26. Moreno, A., Myller, N., Sutinen, E., Ben-Ari, M.: Visualizing programs with Jeliot 3. In: AVI 2014, Working Conference on Advanced Visual Interfaces, pp. 373–376. ACM (2004)

27. Roels, R., Meştereagă, P., Signer, B.: Towards enhanced presentation-based teaching of programming: an interactive source code visualisation approach. In: CSEDU 2015, 7th International Conference on Computer Supported Education, pp. 98–107. SCITEPRESS (2015)
28. Roels, R., Signer, B.: An extensible presentation tool for flexible human-information interaction. In: Demo Proceedings of BCS HCI 2013, 27th BCS Conference on Human Computer Interaction, p. 59. British Computer Society (2013)
29. Roels, R., Signer, B.: A unified communication platform for enriching and enhancing presentations with active learning components. In: ICALT 2014, 14th IEEE International Conference on Advanced Learning Technologies, pp. 131–135. IEEE (2014)
30. Roels, R., Signer, B.: MindXpres: an extensible content-driven cross-media presentation platform. In: Benatallah, B., Bestavros, A., Manolopoulos, Y., Vakali, A., Zhang, Y. (eds.) WISE 2014, Part II. LNCS, vol. 8787, pp. 215–230. Springer, Heidelberg (2014)
31. Sa, L., Hsin, W.J.: Traceable recursion with graphical illustration for novice programmers. InSight: J. Sch. Teach. **5**, 54–62 (2010)
32. Smith, P.A., Webb, G.I.: Reinforcing a generic computer model for novice programmers. In: ASCILITE 1995, 7th Australian Society for Computer in Learning in Tertiary Education (1995)
33. Smith, P.A., Webb, G.I.: The efficacy of a low-level program visualization tool for teaching programming concepts to novice C programmers. J. Educ. Comput. Res. **22**(2), 187–216 (2000)
34. Sorva, J., Sirkiä, T.: UUhistle: a software tool for visual program simulation. In: Koli Calling 2010, 10th Koli Calling International Conference on Computing Education Research, pp. 49–54. ACM (2010)
35. Tufte, E.R.: The Cognitive Style of PowerPoint: Pitching Out Corrupts Within. Graphics Press, Cheshire (2003)
36. Velázquez-Iturbide, J.Á., Pérez-Carrasco, A.: InfoVis interaction techniques in animation of recursive programs. Algorithms **3**(1), 76–91 (2010)
37. Virtanen, A.T., Lahtinen, E., Järvinen, H.M.: VIP, a visual interpreter for learning introductory programming with C++. In: 5th Koli Calling Conference on Computer Science Education, pp. 125–130 (2005)

Customizable Learning Scenarios for Students' Mobile Devices in Large University Lectures: A Next Generation Audience Response System

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Abstract. Audience Response Systems are a common sight in today's university lectures. They are used to increase student's motivation, self reflection and activation during large lectures with up to hundreds of students. The wide distribution of mobile devices supports this development, as teachers no longer have to hand out special hardware clickers, but can build on a variety of mobile web applications, which are able to perform classroom activities, like quizzes, lecture feedback and brainstorming. Therefore, most systems do either support a reasonable amount of basic scenarios or are very specialized in a few less common scenarios. But teachers often want to customize an established scenario for their own needs. This could be a small variation like an additional information text to a multiple choice question up to a more complex background logic to perform live experiments. Therefore, we developed a model and wrote a prototype which enables the users to customize their established learning scenarios or even build novel ones. Our teachers are now able to design and customize their own in-class learning scenarios, fill them with their content, use them in their lectures and reflect the results with their students. But besides the technological capabilities, designing a well-founded learning scenario still needs a certain amount of time and didactic experience.

Keywords: Audience response systems · Clickers · Quizzes · Learning scenarios · Peer instruction · Lecture feedback.

1 Introduction

Audience Response Systems (ARS) are common tools used in many lectures nowadays. The early implementations were created on PDAs and hand held computers to increase interactivity, activate the audience and get feedback about the students' knowledge [1]. With today's availability of smart mobile devices, the usage of ARSs within university classroom settings has become more and more popular.

Due to the didactic benefit, the number of ARS implementations grew further during the last years. Most applications offer a similar amount of functionality

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and fit for the purpose of a specific classroom learning scenario, like test questions, self-assessment or direct audience feedback. We also implemented an ARS at our university three years ago and integrated it into our learning management system ILIAS[1] [2]. The *MobileQuiz* based on the students' mobile devices as clicker devices, used a QR code for a fast and lightweight access and has been used in many lectures by now.

But with the increasing popularity, more and more requirements for extensions were addressed to us. These requirements ranged from simple layout adaptations to enhancements of the number of different question types up to new learning scenarios with their own customized logic. Beginning with simple feedback and self-assessment scenarios, our lecturers wanted to have customized learning scenarios with more complexity, adaptivity and increased student interactivity. They wanted to use guessing questions with a range of right answers, text input for literature discussion, twitter walls for in-class side discussions, game-theory and decision-making experiments for live demonstrations. Every lecturer had a precise picture of his needs that differentiated from the existing scenarios and the requirements of the other lecturers.

Meeting the lecturers' needs by adding new question types and extensions in the existing quiz logic required an additional programming effort for every new scenario. Even little variations in appearance needed a change in the program code, and new features like an adaptive and collective quiz behavior would have needed a full reconstruction of the existing application or an entirely new tool for this purpose. We wanted to meet all the requirements in one step by allowing the lecturers to configure the classroom learning application for their learning scenario without the limitation of existing tools and without implementing every change into the source code. We thus designed a model [3], able to depict many different kinds of in-class learning scenarios on mobile phones and created an application, implementing that model: the *MobileQuiz2*. Our model is able to describe the appearance and behavior of many different learning scenarios by using a small set of predefined elements. As a result, our prototype application comprises the features and possibilities of many other tools within one system. Figure 1 shows three possible scenarios as seen on a mobile phone. The right figure shows a basic quiz with multiple choice and singe choice questions. The figure to the left shows a question with a picture, a free text input and a progress bar, whereas the scenario in the center only uses five point Likert scale sliders without a submit button but with direct input for a dynamic live result chart.

The blueprint for a learning scenario is written as an XML language file and therefore very vulnerable to errors during the creation. We created a graphical scenario editor which simplifies the editing for that reason. But lecturers without a computer scientists background still have problems to map their ideas into the applications structure.

We tested the usability of the scenario editor with four of our lecturers and the validity of our model and application in three different courses with up to fifty students and altogether 27 classroom sessions [4].

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[1] http://www.ilias.de.

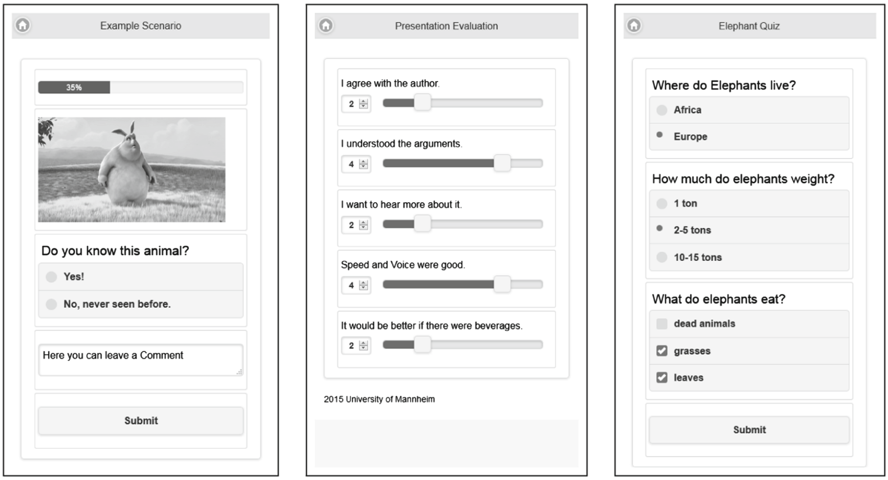

Fig. 1. Screenshots of students' phones of three different scenarios during the activity phase.

In this paper, we discuss the previous ARSs with their benefits and drawbacks and the technologies we adapted from other fields of knowledge in Sect. 2. In Sect. 3, we briefly describe the approach and the modeling of the data. We present new functionality and details of our extended ARS at the example of the *MobileQuiz2* application in Sect. 4 and explain the novel graphical user interface for the scenario editor. In Sect. 5, we describe the evaluation of the model, the performance of the prototype and of the new scenario editor. Section 6 discusses the benefits, difficulties and limitations and gives a conclusion about the current state of development and an insight into the current and future work.

2 Related Work

2.1 Benefits of Audience Response Systems

In everyday teaching, time restraints and the number of students in a course can hinder the usage of beneficial methods like group works, feedback sessions or plenum discussions. In this case, e-learning technology can offer time-effective alternatives or supplements. A prominent example is the use of ARS. These systems can be used to anonymously test students' understanding of a learning unit. Besides, students can be asked for their opinion concerning course contents or course design. These answers can be a starting point for further explanations or face-to-face discussions. Numerous research has shown positive effects of ARS: Students think that their learning success in courses with ARS is higher [5–7], the courses are rated less boring [8] and their motivation is increased [5]. The usage of ARS also leads to a significantly higher learning success [9]. But besides high asset costs for commercial solutions, most of the ARS are functionally restricted to multiple choice, numeric and similar answer formats. The didactic benefit is therefore limited to the realizable scenarios. When designing a course, the lecturer searches for the tools and methods he needs to realize his teaching goals. At this point, lecturers often face the problem that there is no tool fitting exactly their needs and expectations. In other cases, lecturers use the tools for the sake of the tools, not taking into account that the tools have to be subordinated to their teaching goals. Reasonable course planning therefore needs flexible instruments that can actually fit the stated goals. Hence, we want to offer a modular construction system that can be used according to the individual demands of the lecturers.

2.2 Current Audience Response Systems

The aim of early systems like Classtalk [10] was to improve the involvement of every single student. The teacher transferred three to four Classtalk tasks per lesson to the students' devices, which were calculators, organizers, or PCs at that time. ConcertStudeo already used an electronic blackboard combined with handheld devices [11] and offered exercises and interactions such as multiple-choice quizzes, brainstorming sessions, or queries.

Basing on that, Scheele et al. [1,12] developed the Wireless Interactive Learning (WIL/MA) system to support interactive lectures. It consisted of a server and a client software part; the latter runs on handheld mobile devices. The components communicate using a Wi-Fi network specifically set up for this purpose. The software consisted of a multiple choice quiz, a chat, a feedback, a call-in module and was designed to be easily extendable. The main problem was that students needed to have a JAVA compatible hand-held device, and they needed to install the client software before they could use the system.

Murphy et al. and Kay et al. discussed advantages and disadvantages of commercial ARS [13,14]. The authors pointed out that the purchase of hardware devices may cause a lot of additional overhead like securing devices against theft, updating, handing out and collecting the devices, providing large number of batteries, handling of broken devices, and instructing teachers as well as students about its usage. Other disadvantages are higher prices of dedicated devices as well as poor maintenance by students.

By now, students' mobile devices evolved in technical functionality and propagation, so that they not only allow an easy interaction with the device but also support the visualization or playback of multimedia content like audio, text, images, or videos [2]. This new generation of lightweight ARS could also be used more easily in combination with different learning materials like lecture recordings and e-books [15]. One major advantage of such systems is the possibility to get feedback about the learning progress and to allow teachers to continuously monitor the students' preparation of a course.

Recent research on audience response systems focused on improving the flexibility and expandability of such systems. Web-based systems have been proposed like BrainGame [16], BeA [17], AuResS [18] or the TUL system [19]. The research focuses on improved user interfaces that allow lecturers to add new questions on the fly, to create a collection of questions, or to check answers immediately.

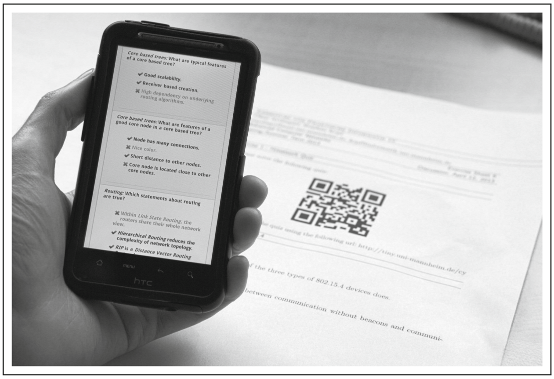

Fig. 2. Example of an QR Code usage on an exercise sheet [21].

When developing a tailor-made ARS from scratch, we defined three main requirements for our application [2]: (1) No additional software needs to be installed on students' mobile devices. (2) Almost all mobile devices should be supported so that no extra hardware has to be purchased. (3) The system should be integrated into the learning management system of the university.

In our opinion, it is much more suitable to require a web browser only, which is supported by every smart phone, notebook, or tablet PC.

Figure 2 shows a situation where scanning a QR code printed on an exercise sheet is the only necessary step for entering the quiz. Other tools like *PINGO* [20] used similar approaches via a QR code for connecting to a quiz round. But all discussed ARS have a limited ability for adaptation. Predefined question types are typically supported well, but the effort for providing new functionality is usually very high.

2.3 Generic Approaches

The main disadvantage of the discussed ARSs is the high effort when adding or modifying new functionality to existing systems. Usually, every new question type needs an additional implementation and every variation of a lecturer's scenario has to be developed for itself.

Few other systems were developed to offer more flexibility and extensibility like more task and answer formats or support of individual feedback. *MyMathLab* is one prominent example that was evaluated as highly useful to improve the math skills and learning success of the students [22]. The system analyses the learning progress of students and generates equivalent tasks. Another example comes from Edgar Seemann who created an interactive feedback and assessment tool that 'understands' mathematical expressions [23].

In our approach, we also integrated some conceptual ideas from MOOCdb [24], which uses a generic database schema to store many different types of learning content within a small number of database tables. The benefits are, that analyses can compare different types of learning content more easily and new types can be added without changing the database structure.

Consequently, we also wanted to extend the flexibility, adaptivity and extensibility of our system and offer a highly generic software tool. Instead of focusing on math skills, our software tool is applicable to a wide range of subjects, easily extensible and can be fully customized to the lecturers learning scenario.

3 Model

Our concept is based on the following assumptions:

- the process of creating a learning unit is divided into five phases,
- every mobile learning scenario is constructed out of a few basic elements, and
- the visualization for the lecturer and the presentation for the students can be deduced automatically from the configuration of these basic elements.

The following subsections discuss the model that has been derived from these three assumptions.

3.1 Phases

We divided the process of a learning unit into the five phases listed in Table 1. The phases are *blueprint* definition, *implementation* of a concrete scenario, perform an *activity*, discuss the *results* and *analyze* the efficiency.

Table 1. The five phases of our learning scenarios.

Phase	Description	Example
Blueprint	Definition of a learning scenario	Define a presentation feedback scenario with five-point Likert scale answer sliders and a submit button.
Implementation	Implementation of a concrete entity of a scenario	Create an implementation with three concrete feedback aspects.
Activity	Performance of a classroom activity	Perform this implementation during a seminar of political sciences.
Result	Presentation of the result	Discuss the results of the activity at the beginning of the next lecture.
Analysis	Analysis of students behavior and scenario success	Analyse the overall results of the whole semester.

The blueprint phase consists of stating the learning goals of the course unit and defining the concept of the learning scenario. According to the learning goals, this can be a personal knowledge feedback, an in-class twitter wall, a live experiment in game theory or an audience feedback on the current talking speed. The lecturer has to define the elements and appearance on the students' phones, the interactions between the participants and the compilation of the charts she wants to present and/or discuss in the classroom. Here, the decision is made whether the learning scenario consists of a single submit button or a more complex compilation of buttons, check-boxes, input fields and rules, for example, to simulate a full marketplace situation in an economics class. This phase needs a fair amount of structural and didactic input, because different scenarios can serve different functions. Every scenario has to be structured carefully in order to support the learning process of the students. So, if the scenario contains many buttons, charts and input fields, students are overstrained by the setting, unable to solve the task. On the other hand, an overview of the learners understanding of the current material is hardly possible with a simple twitter-wall when it comes to large groups, as the number of results are not usefully structured.

After defining the scenario's blueprint, lecturers can take a predefined scenario in phase two and create a concrete *implementation* of it. If the scenario is, e.g., a classroom response scenario for knowledge assessment, the concrete questions and possible answers are entered now.

These implementation is then used to perform a classroom *activity* with the actual students (phase 3). Every activity is persistent and can be used many times in different lecture groups or at different times. Activities can take a short time period, e.g. for a small self assessment test at the beginning of a course, or a longer period, e.g. for self-regulated student exam preparation, for surveys or course evaluations.

In phase 4, the student input can be displayed as *result* charts. Depending on the type of input data, the results are displayed as text, coloured bar charts or summarized pie charts. The colors red, green and blue are automatically used for wrong, correct and neutral answers.

The last phase is mostly for analyses of the learning behavior and the didactic research. Everything entered by the students is logged, and this data can then be used to perform learning analytic research. The data also allows evaluating all learning scenarios under different conditions. We do not track any user specific data, we collect the data of the participating students or teachers anonymously.

3.2 Basic Elements

A classical board game has many similarities compared to an ARS when considering the most important elements. A classical game usually consists of different objects like tokens in different colors, cards with text, or resource coins of different values. *Objects* also exist in a learning scenario and could e.g. consist of questions with answers. Comparable to a board game, these objects also have attributes, for example, whether a question is correct in the case of multiple choice questions or which types of answers are allowed.

Beside the tokens and the board itself, a game has *rules*. They describe the logic behind the game and the way the players interact with the game elements

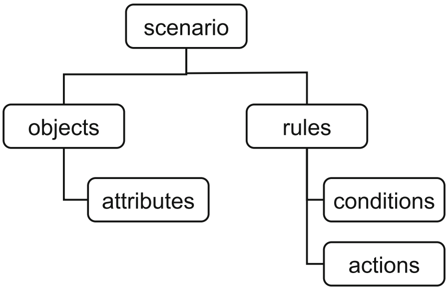

Fig. 3. Relation of scenario elements.

and with each other. Rules are also required for the implementation of an ARS. *Objects* and *rules* already specify the main elements that are the basis for all learning scenarios (see Fig. 3).

Objects are elements holding information, and they have relations to each other. Every object can hold a set of *attributes*, which store the actual data. An attribute can be the text of a question, a check box for an answer or a button for a submit. Every rule consists of a set of *checks* and *actions*. Checks describe the conditions under which the rule gets activated, while actions describe the action that has to be performed. This covers very simple rules, like a button-click triggering a player's counter to increase by one, to very complex ones where a sum of an attribute of all players exceeds a given value, or every player with less than five correct answers gets a warning message on his display.

Whereas rules with checks and actions can be stored once in the database, the activity elements (objects and attributes) have to be stored for every main phase (blueprint, implementation and activity) separately. Objects and attributes of the scenario build the blueprint for the entities (of the different implementations), which are then copied for every activity and player. Scenario objects and attributes store information about the general structure of the learning scenario (e.g., a multiple choice test), implementation objects and attributes store information about a concrete topic (e.g., questions about elephants), and activity objects and attributes hold the data of one activity and player (e.g., a player's answers to the test).

The information for the phases result and analysis are mainly stored in the activity objects and attributes. Beside that, we log additional information about user behaviour in two separated tables, which are used for meta analysis and application improvement.

3.3 Generic Approach

We tried to follow a generic approach to keep complexity and configuration effort as low as possible. Therefore, we use the same information in every phase differently. This involves the visibility of objects and attributes, the appearances in form and color, as well as default texts. If an attribute has the type boolean, it

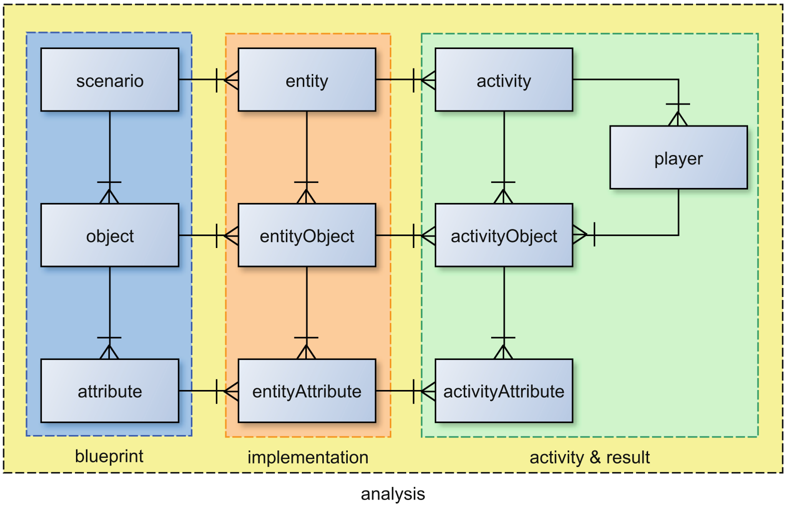

Fig. 4. ER diagram of the core database tables structured in the five phases.

is false by default and is displayed as a check box on the students' devices. If it is marked to be displayed as a bar chart, the true and false values of an activity will be summarized and displayed as green and red bars. A bar chart about other values, such as different car models, will be displayed in neutral blue bars. A text

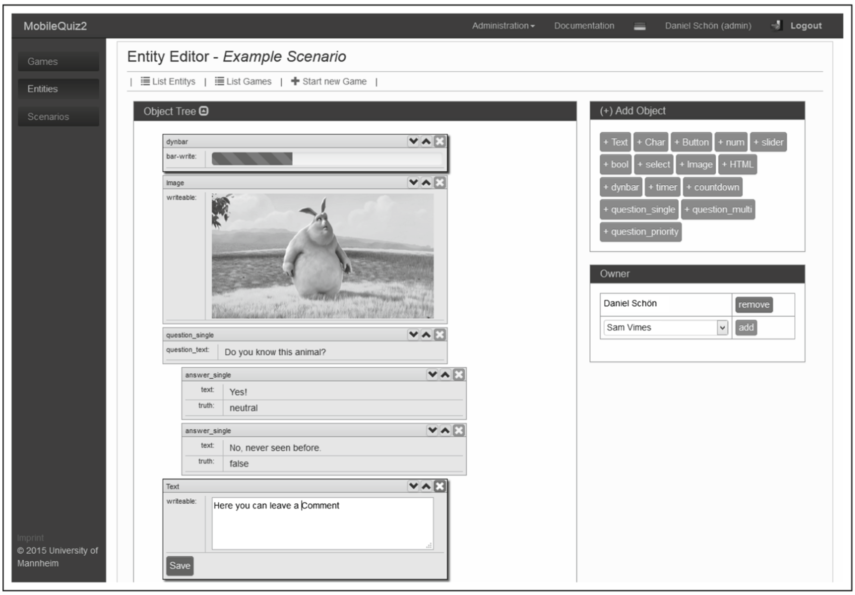

Fig. 5. Screenshot of the entity edit page of the MobileQuiz2.

attribute marked as *writeable* will be displayed as an input text element, whereas an attribute marked as *readable* will be shown as a simple HTML text label. An attribute of a numeric type only accepts numeric input. The right screen-shot of Fig. 1 shows the rendered activity view on the students' devices, which is based on the lecturers implementation of the scenario in Fig. 5. The text of the multiple choice question is a readable text, whereas the comment is editable.

4 Prototype

Our aspiration is to have an easy to use application providing the students with a fast and easy access via a QR code displayed on classroom screen and the lecturers with an integrated teaching tool. Besides using existing scenarios, such as classroom quizzes, the tool should be easy enough for lecturers to create their own, customized scenarios.

We have implemented a prototype of the described model as a proof of concept and to provide a powerful tool for learning scenario analyses, the *MobileQuiz2*. It is written in PHP and uses the ZEND2[2] framework which already contains many useful functionalities. We used modern web technologies like AJAX, HTML5, CSS3 and the common web frameworks jQuery[3], jQuery Mobile[4] and jqPlot[5].

In an optimal process, a lecturer would start with an idea for a new in-class learning scenario. She then discusses this idea with a didactic expert and defines the scenario model. The expert defines the scenario as an XML file and uploads it to the prototype application. So far, the prototype supports typical attribute types like text, numbers, boolean values and more specialized ones like time, progress bars, images and buttons. For the implementation of the logic, the rules support logical operators, basic and medium complex math operators like arithmetic mean and sum, and visual operators for hiding and displaying specific attributes or objects.

After defining the scenario, a lecturer can then choose it to implement his own entity. Figure 5 shows the current editor for building a new implementation. While new scenarios are available to every lecturer, implementations and activities have restricted rights for the respective owner.

Lecturers can start a new activity of any of their implementations at any time. With the start of an activity, a new QR code is created and can be used within the classroom or with any other medium like videos or exercise sheets (see Fig. 2). We use a shortened URL to generate a QR code, which is the main entrance point for the audience. Students can then access the activity with any JavaScript-supporting, internet enabled device via the URL. The page is only loaded once, and every change or user action is sent to the server via an AJAX request. After processing the rules and changes on the server side, the student's

[2] http://framework.zend.com/.
[3] http://jquery.com/.
[4] http://jquerymobile.com/.
[5] http://www.jqplot.com/.

mobile browser gets an AJAX response with the relevant attribute information. The page content and layout are changed through JavaScript without the need of a page refresh. After performing an activity, the results can be discussed with the audience or used for the preparation of an upcoming lecture. Our application stores meta data so that all kind of analyses of the students' behaviour can be done afterwards. Beside technical information about the participating devices, the users' activity, the line of action and the performance of the students are tracked anonymously.

In an actual lecture the system could be used as follows: A lecturer in game theory (business economics), wants to conduct a live experiment. The game is called *Guess* $\frac{2}{3}$ *of the average.* In this experiment, every participant has to choose a number between 0 and 100. The winner is the one closest to $\frac{2}{3}$ of the mean value. The lecturer first talks to our didactic expert and they decide to model a scenario with a numeric input field and a submit button. If students click the submit button without any number or with a number bigger than 100, a warning text is displayed, otherwise the button and input field disappear and a text message appears.

After a given amount of time, the mean value is calculated together with the corresponding $\frac{2}{3}$ value. The student with the smallest distance to this value sees a winning message. Our expert now models this scenario within an XML file and uploads it to the prototype application. The lecturer then chooses this scenario within the application to implement an entity of it and gives it the name of his lecture and some describing text. She enters the entity editor and chooses an amount of time for this implementation. During her lecture, she opens the course page within our university's LMS and starts a new classroom activity. The students participate in the experiment and while the winner is happy about his guess, the lecturer displays and discusses a chart of the distribution of all answers with the whole class.

4.1 Scenario Editor

The *MobileQuiz2* follows a generic model, which allows the creation of a large amount of different in-class learning scenarios. But first practical tests showed, that with the growing scenario complexity, the designing effort increases magnificently. The creation and combination of objects, attributes and rules requires a basic understanding of programming concepts, while knowledge and information of the systems logic in depth are needed as well.

Additionally every scenario had to be defined in an XML structure. This prevents lecturers and other users, who do not have a deep knowledge in XML and the *MobileQuiz2* itself, to create and change scenarios by their own. In order to make this step more facile and manageable for all users we decided to extend our application by a new editor feature, which supports the graphical creation of learning scenarios. Figure 6 shows the current user interface of the scenario editor. The editor can be used for the creation as well as for the editing of existing in-class learning scenarios.

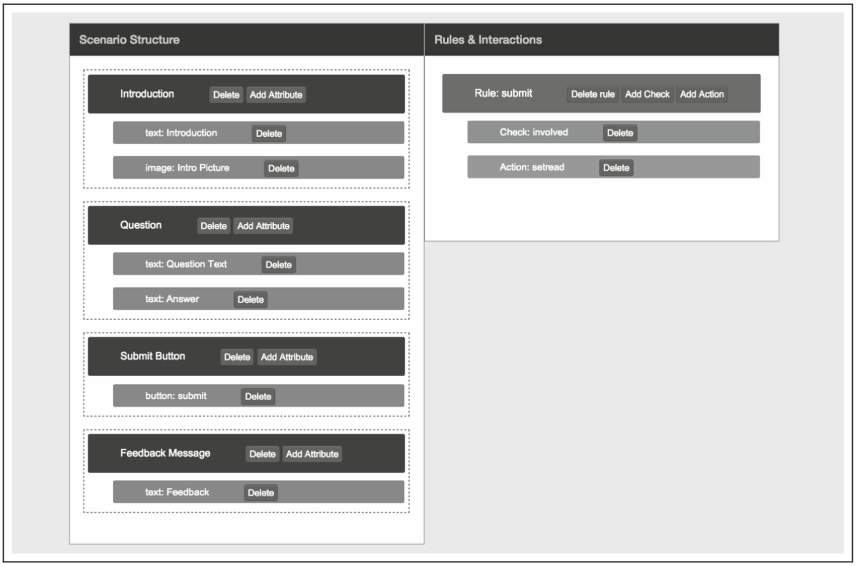

Fig. 6. Scenario editor showing a scenario's structure.

A full flexibility in the editing of scenarios, which does not limit our generic model's capabilities is an important requirement we have determined for the new editor feature. In doing so we strictly orientate towards our model's definition of a scenario, by providing the possibility to add default components. Such default components can be objects, attributes and rules and are initially blank to be configured unrestrictedly later on. The idea behind is to give users the full flexibility to customize learning scenarios along their needs without restrictions. Especially experts and already experienced users with the high demand for customization shall benefit from those possibilities.

But such an approach does not solve our problem of supporting also non-expert users. Inspired by common rapid e-learning authoring tools the scenario editor additionally provides a set of so called predefined components. Those predefined components are small modules, which already define a number of popular and also complex scenario constructs for quiz elements. Various components like choice questions, such as multiple-choice and single-choice questions for example, but also other simple and complex elements like submit buttons can be contemplated as predefined components.

Further components are conceivable as well and can be added to the editor easily.

5 Evaluation

We evaluated the proposed model in real classroom settings to proof the practicability of our concept. The goal of this first evaluation was to observe the model's behaviour under real classroom conditions, to rate the model's validity with its boundaries and drawbacks, to monitor potential performance parameters, and to gain experience in typical lecture scenarios. We modelled eight different learning scenarios and used the prototype application in five large exercises and twenty-one small exercise lessons in an informatics course and a media didactic seminar. About twenty students participated in the small exercises, about 30 in the seminar and up to fifty in the large exercise. The scenario editor was evaluated by four lecturers in 45 min sessions.

The goal of the informatics scenarios was to investigate different scenario parameters on students' acceptance. The used scenarios were mostly multiple-choice feedback scenarios with differences in structure and appearance. Among other things, one of the scenarios investigated the differences between an open text answer format and predefined single choice answers. Later on, we hid following questions until the visible ones were answered and showed a progress bar to increase students' overview of how far they proceeded.

The purpose of this study was to give a proof-of-concept that our prototype enables the researcher to model the different scenarios and to investigate the impact of the different parameters without having an informatics background. We then used the experience of the lecturer and the generated data to get a qualitative feedback of our approach.

5.1 Models Performance

We recorded the delay times of every user action and collected over 37.000 delay times in over 25 lectures.

When entering the active scenario, in about 70 percent, it could be accessed in less than half a second. But slightly more than 10 percent of the joinings took more than one second.

Every five seconds a refresh is performed in the background and is not triggered by an active user action. Data changes triggered by other users are transported via such refreshes. About 90 percent of the background updates are performed within one second.

We experienced, that users distinguish between delay times of different actions. They expect different reaction delays between clicking a button and selecting a check-box. Figures 7 and 8 show the delay times after actively clicking a button

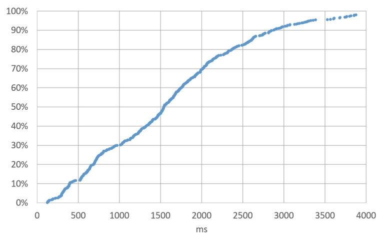

Fig. 7. Delay time after clicking a button.

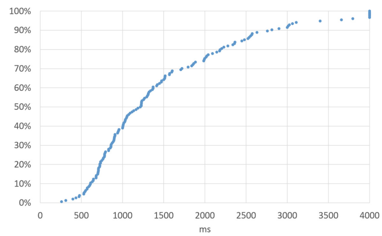

Fig. 8. Delay time after using multiple choice menu.

or a choice box. Whereas clicking a button typically triggers an event, that can be expected to take some time to be performed, selecting a choice box is expected to be accomplished immediately. Unfortunately, the delay times are high in both cases. Only 30 percent of button clicks, 40 percent of multiple choice selects and only 20 percent of single choice selects were executed in less than one second.

5.2 Models Capability

We researched seven different scenario parameters including graphical and textual problem descriptions, different color schemes, the use of a progress bar and text input with special characters [4]. Figures 9, 10 and 11 show the most interesting results.

Figures 9 and 10 show a scenario where the first group got a class diagram in a JAVA course represented as a figure, whereas the other* group got a textual description of the class relations. The figures show that there was not much difference in user experience between the two scenarios. We expected the picture scenario to be favoured but about two third of the students rated both scenarios as pleasant or very pleasant. Respectively, one third was not pleased with both scenarios. As reasons they stated the clarity in both cases. They had to scroll up to the picture and down to the answers for every question. In the other case, they mentioned the pure amount of description text as too much and visually unstructured. Interestingly, the group with the picture answered questions about the relationship between the classes more precisely, whereas the other group was superior in questions about the class details [4].

Figure 11 shows the results when students had to use source code within their textual answer. Source code contains many special characters and is more difficult to enter on a mobile phone. Usually, special characters like square brackets and the ampersand are on a second or third page of a mobile phone keypad and therefore not directly visible. But more than about the input of special characters, the students complaint about the size of the input text field as they thought it was small to keep the overview over open and closed brackets [4].

5.3 Graphical Scenario Editor

We evaluated the graphical scenario editor by interviewing four lecturers in 45 min sessions. Three of them were teachers in computer science whereas one has a didactic background. After a short introduction, the participants got three tasks, which involved the customization of three possible scenario blueprints. These tasks varied in their level of complexity and ranged from using predefined components up to defining own rules and scenario logic. Afterwards, they were free to give qualitative feedback as part of a questionnaire. The results showed, that the scenario editor was quite helpful, particularly for people without any knowledge in writing XML documents. It further turned out that predefined components were popular among the test persons, since they were easy to use and they facilitated the composition of new scenarios during the first steps with the editor. Nevertheless the understanding of the models structure with objects

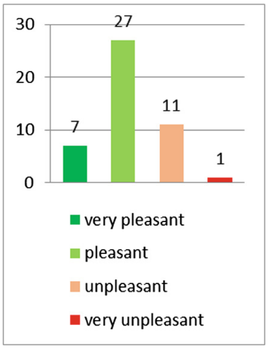

Fig. 9. Multiple Choice with picture.

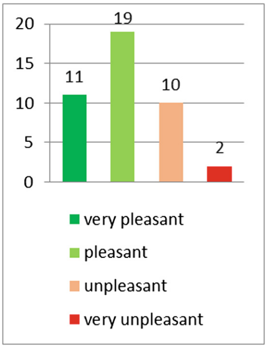

Fig. 10. Multiple Choice with text description.

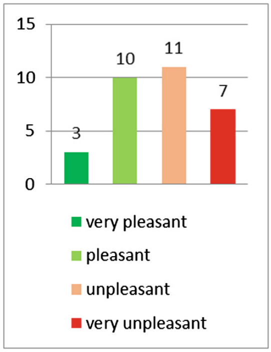

Fig. 11. Scenario with source code.

and attribute needed some explanation and nobody was able to fully grasp the correct application of rules and logic.

6 Discussion of the Results

6.1 Model

As we know today, our model is able to represent every scenario mentioned so far. Objects with a variety of attributes can be created, and the rules are able to describe a complex, adaptive and interactive scenario behaviour. During the evaluation, we were not only able to model the scenarios we had planned from scratch, but we were able to react on unforeseen requirements, too. With the increasing understanding of the potential to customize their learning scenario the lecturers wanted further changes in existing scenarios which we could do by editing only the XML structure and without touching the applications source code. The lecturers mainly used scenarios with multiple-choice and text questions. They then extended the behaviour, so that further questions appeared depending on the given answers during the quiz. For the big exercise, they modelled a complete question catalogue of different topics and let the students decide for themselves which field they wanted to work on. The lecturers gave us a homogeneous positive feedback on the possibilities our model gave them to define their own lecture scenario. After getting customized to the objects, attributes and rules, they began to further enhance and diversify the scenarios on their own.

6.2 Performance

After our model-based tool passed the first scenario tests, we ran into vast performance issues during the first big exercise. The amount of activity attributes (cf. Fig. 4) increased rapidly with the number of participants, up to five thousand per activity. Unoptimized algorithms of rule execution, together with a five seconds refresh, finally crashed the web server. After optimizing the application's algorithms, we decided to track the times more specifically to identify potential bottlenecks and get better background information.

The usual response times were in a range that our students accepted as normal behaviour for a web application. The long response time for using a button is mostly accepted, because students expect something to happen after clicking at one. But even so, during scenarios with a complex body of rules, the experienced delay came close to the threshold of dissatisfaction. Refresh and data input actions mainly run in the background, so that they do not experience waiting times and don't recognize if they got an updated information with a delay. However, similar delay when selecting a choice box is not accepted. Students expect an immediate feedback when using a basic HTML element and do not tolerate unusual delays.

6.3 Usability

The handling of the system for the students is fast and easy. It affords as little technical understanding as writing a short message or using mobile applications, as we use the common application elements and libraries. Even the scanning of a QR code has become a common task, and students are familiar with writing longer passages of plain text on their smart phones.

The usability for the lecturer depends on the phase. Implementing a new entity of an existing scenario only needs some basic understanding of the system. It is quite similar to the usage of tools mentioned in Sect. 2 as we can design scenarios to appear the way they these tools behave. But usability also depends on the scenario's complexity. Opening a new topic for a twitter wall would need far less effort than defining questions and answers for several rounds of adaptive multiple-choice questions. We have experienced no conspicuousnesses in the usability for the lecturers so far, but we have not examined feedback for a significant number of subjects yet.

In contrast, creating a scenario blueprint with objects, attributes and rules still needs a basic understanding of programming concepts. The practical tests with the scenario editor exposed that it is still quite complex for users, who do not have the specific understanding how a scenario has to be depicted to meet the application's requirements. Especially with the growing complexity of a scenario, the test persons were not able to solve the tasks without additional assistance. In the end, the trade-off between usability and the provided complexity to author all possible scenarios, which can be described by our model, turned out to be quite challenging.

As it is recommended to consider didactic principles in new scenarios, we are planning to support the creation of new scenarios by our university's didactic center. Depending on the complexity of the desired scenario, phase one can take from fifteen minutes up to several hours.

6.4 Didactics

The advantages of our development are essential: at the current state of development, lecturers can create new scenarios that fit their needs, with only the initial help of an didactics expert. No programming expert is needed. They no longer have to search for other specialized tools to realize their planned learning scenarios. The usage of defined scenarios during preparation and execution of the lecture is manageable for the lecturer himself.

But even with valuable editor, creating a new learning scenarios on the basis of the teaching and learning goals is not self-explanatory. Profound didactic competences or at least a good intuition are necessary to design a useful and effective learning environment. Therefore, we realized an educational consulting service that also includes help with the technical realization of individual courses and scenarios. With the new software tool, students benefit from even more varied and activating teaching methods in comparison to the original *MobileQuiz*. Against our assumption, experience showed that students even like to type longer free texts into their smart phones in order to answer questions. This offers additional didactic possibilities concerning the course design. Using our tool, we do not track any user specific data of students or lecturers. This allows us to perform many analyses without data privacy issues, but disables the opportunity for individual grading or long term tracking.

7 Conclusions

We presented an application for customizable learning scenarios based on a flexible model. By dividing the whole process into the five phases: *blueprint*, *implementation*, *activity*, *result* and *analysis*, we are able to describe a large amount of different scenarios within one model. We did a first proof of concept in more than 25 university exercises with up to 50 students, investigated the model's capability, the application's performance and the usability for the lecturers. Our results showed that the model is valid and satisfies the expectations. A graphical scenario editor enables the lecturers after a short introduction to customize their scenarios on their own. The application is further able to support didactic analysis on learning scenarios. We investigated seven parameters of learning scenarios on mobile devices and showed, that the underlying model meets the expectations.

We are now improving the prototype and are focusing on performance, stability and lecturers' experience. We are further implementing the tool in the university's learning management system to grant an easy accessibility and usage for the lecturers, also for these without programming experience. Even in the current state of implementation, we experience a high interest of our lecturers who want to use the new application in their lectures.

We are steadily increasing the number of lectures using the enhanced learning scenarios at our university. We are planing several scenarios together with the didactic psychology sciences this semester, to investigate specific learning parameters in university lectures. The *MobileQuiz2* will then show its value as a didactic research supporting tool. Besides, we will further extend its overall functionality and analysing capabilities.

We also aim to improve the scenario editor by adding new features, which enhance the usability. The goal is to provide a tool, which enables non-expert users to create more complex scenarios, without having the deep knowledge of programming concepts and our system, while maintaining the generic model's capabilities.

We further establish technical and educational expertise at the university's didactic center to support lecturers in defining new mobile learning scenarios and enhancing their classroom interactivity in novel ways. With the growing amount of users, we plan to look at more didactic centered focuses (like the creation of educational patterns).

References

1. Kopf, S., Effelsberg, W.: New teaching and learning technologies for interactive lectures. Adv. Technol. Learn. (ATL) J. **4**, 60–67 (2007)
2. Schön, D., Klinger, M., Kopf, S., Effelsberg, W.: MobileQuiz – a lecture survey tool using smartphones and QR tags. Int. J. Digit. Inf. Wirel. Commun. (IJDIWC) **2**, 231–244 (2012)
3. Schön, D., Klinger, M., Kopf, S., Effelsberg, W.: A model for customized in-class learning scenarios an approach to enhance audience response systems with customized logic and interactivity benefits of audience response. In: 7th International Conference on Computer Supported Education, CSEDU. SCITEPRESS - Science and Technology Publications, Lissabon (2015)
4. Schön, D., Yang, L., Klinger, M.: On the effects of different parameters in classroom interactivity systems on students. In: Carliner, S., Fulford, C., Ostashewski, N. (eds.) EdMedia: World Conference on Educational Media and Technology, Montreal, Quebec, Canada, pp. 721–729 (2015)
5. Ehlers, J.P., Möbs, D., vor dem Esche, J., Blume, K., Bollwein, H., Halle, M.: Einsatz von formativen, elektronischen testsystemen in der präsenzlehre. GMS Zeitschrift fur Medizinische Ausbildung **27** (2010)
6. Uhari, M., Renko, M., Soini, H.: Experiences of using an interactive audience response system in lectures. BMC Med. Educ. **3**, 12 (2003)
7. Rascher, W., Ackermann, A., Knerr, I.: Interaktive kommunikationssysteme im kurrikurlaren unterricht der pädiatrie für medizinstudierende. Monatsschrift Kinderheilkunde **152**, 432–437 (2003)
8. Tremblay, E.: Educating the mobile generation – using personal cell phones as audience response systems in post-secondary science teaching. J. Comput. Math. Sci. Teach. **29**, 217–227 (2010)
9. Chen, J.C., Whittinghill, D.C., Kadlowec, J.A.: Classes that click: fast, rich feedback to enhance student learning and satisfaction. J. Eng. Educ. **99**, 159–168 (2010)
10. Dufresne, R.J., Gerace, W.J., Leonard, W.J., Mestre, J.P., Wenk, L.: Classtalk: a classroom communication system for active learning. J. Comput. High. Educ. **7**, 3–47 (1996)
11. Dawabi, P., Dietz, L., Fernandez, A., Wessner, M.: ConcertStudeo: using PDAs to support face-to-face learning. In: Wasson, B., Baggetun, R., Hoppe, U., Ludvigsen, S. (eds.) International Conference on Computer Support for Collaborative Learning 2003 - Community Events, Bergen, Norway, pp. 235–237 (2003)

12. Scheele, N., Wessels, A., Effelsberg, W., Hofer, M., Fries, S.: Experiences with interactive lectures: considerations from the perspective of educational psychology and computer science. In: Proceedings of the 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The Next 10 Years! CSCL 2005, pp. 547–556. International Society of the Learning Sciences (2005)
13. Murphy, T., Fletcher, K., Haston, A.: Supporting clickers on campus and the faculty who use them. In: Proceedings of the 38th Annual ACM SIGUCCS Fall Conference: Navigation and Discovery, SIGUCCS 2010, pp. 79–84. ACM, New York (2010)
14. Kay, R.H., LeSage, A.: Examining the benefits and challenges of using audience response systems: a review of the literature. Comput. Educ. **53**, 819–827 (2009)
15. Vinaja, R.: The use of lecture videos, ebooks, and clickers in computer courses. J. Comput. Sci. Coll. **30**, 23–32 (2014)
16. Teel, S., Schweitzer, D., Fulton, S.: Braingame: a web-based student response system. J. Comput. Sci. Coll. **28**, 40–47 (2012)
17. Llamas-Nistal, M., Caeiro-Rodriguez, M., Gonzalez-Tato, J.: Web-based audience response system using the educational platform called bea. In: 2012 International Symposium on Computers in Education (SIIE), pp. 1–6 (2012)
18. Jagar, M., Petrovic, J., Pale, P.: Auress: the audience response system. In: 2012 Proceedings ELMAR, pp. 171–174 (2012)
19. Jackowska-Strumillo, L., Nowakowski, J., Strumillo, P., Tomczak, P.: Interactive question based learning methodology and clickers: fundamentals of computer science course case study. In: 2013 The 6th International Conference on Human System Interaction (HSI), pp. 439–442 (2013)
20. Kundisch, D., Herrmann, P., Whittaker, M., Beutner, M., Fels, G., Magenheim, J., Sievers, M., Zoyke, A.: Desining a web-based application to support peer instruction for very large groups. In: Proceedings of the International Conference on Information Systems, pp. 1–12. AIS Electronic Library, Orlando (2012)
21. Schön, D., Klinger, M., Kopf, S., Effelsberg, W.: Homequiz: blending paper sheets with mobile self-assessment tests. In: Herrington, J., Couros, A., Irvine, V. (eds.) Proceedings of EdMedia: World Conference on Educational Media and Technology 2013, pp. 1446–1454. Association for the Advancement of Computing in Education (AACE), Victoria (2013)
22. Chabi, M., Ibrahim, S.: The impact of proper use of learning system on students' performance – case study of using mymathlab. In: 6th International Conference on Computer Supported Learning, pp. 551–554 (2014)
23. Seemann, E.: Teaching mathematics in online courses - an interactive feedback and assessment tool. In: Proceedings of the 6th International Conference on Computer Supported Education, pp. 415–420. SCITEPRESS - Science and Technology Publications (2014)
24. Veeramachaneni, K., Dernoncourt, F.: MOOCdb: Developing data standards for mooc data science. In: AIED 2013 Workshops, pp. 1–8 (2013)

Learning Arabic Through Play Games on Tabletop Surface Computers in Early Childhood

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Abstract. This paper presents the use of educational games in the context of the "Arabiyyatii" research project, a three-year project funded through Qatar National Research Fund. The scope of the project is teaching Modern Standard Arabic (MSA) to kindergarten students (5-6 years old) that are native speakers of the Qatari dialect. Part of the new curriculum envisioned in the project includes the use of simple educational games, specifically designed and developed for tabletop surface computers. The paper presents a naturalistic study design, following the activities of 18 students for a period of 9 weeks in the project. The paper presents three of the most played games by the students, along with analysis on collected data, focusing on students' performance and attitudes towards the new curriculum. Results analysis provided an encouraging image, suggesting that the conducted activity was able to increase students' engagement in language learning, increase their exposure to MSA, and develop their vocabulary.

Keywords: Educational games · Tabletop surface computer · Language learning · Modern standard arabic · Early childhood

1 Introduction

The use of official and everyday forms of a language can create confusion to young students, as the borders between the two are not always visible. Across the Arab world, Classical Arabic (CA), and its derived form, Modern Standard Arabic (MSA), used in all formal contexts, is perceived as the "high" form of language whereas, the local mother tongues (or "dialects") are used in daily contexts and are usually perceived negatively [1]. As expected, the situation in Qatar is no exception, creating confusion to students (e.g., [2]). As all diglossic languages, the formal form, MSA is the language students learn in schools, while the informal form, the dialect, is the mother tongue spoken at home. As a consequence, the numbers of geographical dialects are various [3], if counted by all 22 Arab countries.

The main goal of our work on the "Advancing Arabic Language Learning in Qatar" project (formerly known as "ALADDIN" for Arabic LAnguage learning through Doing,

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Discovering, Inquiring, and iNteracting, and recently renamed "Arabiyyatii", meaning "my Arabic") is the proposal of an updated comprehensive curriculum for the Arabic language that would integrate the use of innovative educational technology into current didactical methods. Tabletop surface computers have been selected as the innovative technology that would offer a series of new learning affordances and would allow the reconstruction of the traditional classroom in a new way. On the other hand, didactical methods stir away from the commonly used scholastic model, making use of communicative approaches, collaborative learning, and constructionism.

This research draws extensively upon the works of Ibrahim (e.g., [4–7]) pertaining to Arabs language attitudes, the relatedness of the MSA to the dialect and the native speakers awareness, lexical separation as a consequence of diglossia, the use of technologies in Arabic language learning, and language planning and education. For example, in summarizing the current situation of the Arabic language, Ibrahim [7] noted that there is conflict in Arabs towards their language. Native speakers do not know much about the relationship between the different varieties of Arabic (dialects) and the official MSA and they often have trouble identifying which version is needed from them in formal education. To make matters worse, the language teachers often do not receive appropriate education on how to approach this delicate issue. The end result, as Ibrahim puts it, is "a native speaker who is in a life time dilemma" (ibid., p. 360).

The curriculum proposed in Arabiyyatii addresses this issue by applying a holistic approach. The project offers a rich learning experience that includes listening, discussing, writing, storyboarding, and gaming activities. The backbone of the curriculum is Aladdin's folklore story, modified from the original version for content and learning requirements. The story provided the context of the curriculum and was presented to students through a series of 21 video episodes. Each episode lasted 5–7 min and was a sequence of still cartoon images with voice-overs.

For 9 weeks during the Fall semester 2013, we tested the new curriculum in the private Kindergarten of the Qatar Academy in Doha, Qatar. The instructional goal during this study period was to teach a class of 5–6 year-olds the Arabic alphabet and enrich their vocabulary in MSA. Although the project has a wide scope, aiming at a new curriculum, the present paper focuses specifically on the use of the educational games, specifically designed and developed for the project.

2 Study Background

2.1 Arabic Language Characteristics

The Arabic alphabet consists of 28 consonants, 3 long vowels, and 3 short vowels. Short vowels are not written within the word, but either above or below the letter. To provide a clearer picture of the study, it is important to present some of the unique characteristics of the language. Arabic writing has four major characteristics that distinguish it from other languages:

- writing is from right to left
- most letters are connected in both print and handwriting

- letters have slightly different forms depending on where they occur in a word (isolated, initial, medial, and final form)
- Arabic script consists of two separate “layers” or writing: the first is the basic skeleton made up of consonants and long vowels, and the second is the short vowels and other pronunciation and grammatical markers.

As far as pronunciation is concerned, Arabic has one-to-one correspondence between sound and letter, while the writing system is regularly phonetic meaning that words are generally written as they are pronounced. This is crucial in the project, since slight difference in pronunciation of a word in dialect and MSA resulted in different writings.

In the context of the study, teaching the Arabic alphabet focused on two major outcomes: recognition and production of the letters. Production means that the students should be able to write and pronounce clearly the letters of the alphabet, while recognition means audio and visual recognition. The students should be able to recognize a specific letter in a spoken or written word. Production in the project was covered by writing activities and discussion sessions led by the school teacher (result analysis on the writing activities can be found in [8]). On the contrary, the educational games presented here were focused on recognition.

2.2 Computer Games in Education

A plethora of different types and forms of computer games have been used extensively in education. The topic has attracted the interest of many researchers resulting in a very rich literature. Kebritchi and Hirumi [9] provided an overview on the pedagogical foundations of modern educational computer games. The use of computer games has yielded encouraging results in several aspects related to learning. Study findings suggest that appropriate use of computer games could positively affect students’ motivation, increase their engagement, enhance knowledge acquisition, support collaboration, and foster the development of problem-solving skills in primary (e.g., [10]), secondary (e.g., [11]), and tertiary education (e.g., [12]).

Although there are several studies focusing on younger ages (e.g., [13]), little can be found regarding the use of computer games at kindergarten. When looking even closer to the Arabic context of the project, the use of educational software or computer games in formal education is rare, if any.

2.3 Tabletop Surface Computers

Tabletop surface computers are a relatively recent achievement, offering learning new affordances that make them a lucrative and interesting choice in educational technology. Results reported in studies have been encouraging so far. Kerne et al. [14] discussed the roles for interactive systems enabled by touch screen devices in supporting creative processes and aiding in idea formation. Morris et al. [15] examined the educational benefits of using a digital table to facilitate foreign language learning. As documented in Piper [16], the use of multimodal tabletop displays, as a rich medium for facilitating cooperative learning scenarios, is just emerging.

The tabletop surface computers[1] we use in the project allowed us to design learning activities using touch technologies and shared interfaces. The system (also "table" for the rest) has a 40" touch screen that can recognize more than 50 simultaneous touch points. As such, the size of the screen is large enough to provide an ideal physical space for interaction and collaboration for 4 kindergarten students. This was essential in the project. Moving away from the traditional setting of a classroom (strictly defined by desks and whiteboards), the use of a table allows students to gather around in small groups and increases the opportunities for peer interaction and student participation.

Apart from the reconstruction of the physical space, the ability to support several simultaneous touch points and the ample screen space are essential in creating a shared interface. A typical computer has two main entry points, namely the keyboard and the mouse, while a tablet has a very limited number of simultaneous touch points (usually 4–5 depending on the system). On the contrary, a table makes all the items of the interface readily available to all participants, thus being ideal for collaboration.

While designing an application, or a game in our case, for a system such as this, the engineer has to take into account the specific affordances the system offers. A distinct example on how the system specifications affected the design of the games and the learning activity was the issue of the horizontal screen. Since students gather around the table, orientation of the interface and its components should be designed carefully. Similarly, learning design should take into account students' positions around the table. In the project, we applied three different approaches, according to the learning needs of each activity: single fixed orientation, multiple fixed orientation, and freely rotating interface items.

Regarding the technical skills of our target audience, the use of touch technology was essential, since kindergartners usually lack the ability to use a computer. On the contrary, the students had already been exposed to other touch systems, such as smartphones and tablets both at home (parents' devices) and at school (each student receives a tablet pc from the school in the beginning of the year).

3 Method

3.1 Participants

School administration assigned one of the classes enrolled in the "Arabic Studies" course to the study. The class had 18 Qatari enrolled students (9 boys and 9 girls), native speakers of the Qatari dialect. All students were between 5 and 6 years old. Although all students were native speakers of the dialect, they had not been taught MSA before and were novices. The learning goal of the course was to teach students fundamental linguistic skills in MSA such as vocabulary development, letter production and recognition, and proper pronunciation. As we mentioned earlier, there is a one to one connection between pronunciation and writing, and it was the first time during their school life that students had to make a distinction between dialect and MSA.

[1] http://www.samsung.com/uk/business/business-products/smart-signage/specialised-display/LH40SFWTGC/EN.

The total population of the class was available only 8 days during the course of 9 weeks for various reasons (e.g., illness). Usually, the actual number of students in the classroom ranged from 16 to 17.

3.2 Design

The design applied in the study followed a naturalistic study approach, following the activity of the 18 students in the new curriculum for a period of 9 weeks (September 29 – December 4). The instructional goal during that specific period was to teach students the isolated form of the first 12 Arabic letters (from [أ] to [ز], considering ‘alif’ and ‘alif with hamza’ as two different letters).

3.3 Material

The main instructional goal behind the design of the educational games was to support students in letter recognition. In this section, we describe the 3 most played games we used in the classroom, plus one game that was introduced near the end of the study. Several other games, along with their alternative versions (e.g., individual or collaborative play), have been developed in the Arabiyyatii project. However, not all games were introduced and used during the 9-week period during which we had access to the school. This was planned, since some of the games in the project focused on higher level of knowledge (e.g., identify words, instead of letters) and had to be introduced later during the school year.

Storytelling. As we mentioned Earlier, the New Curriculum Was Built around an adapted version of the famous and loved Arabic folklore story of “Aladdin and the Magic Lamp”. Although watching the video episodes of the story was not a game per se, we present the storytelling activity here, because is provided the context and set the tone of the gaming activities that followed.

Although the story is known through many variations, it is very often enriched with additional episodes and characters that fit different contexts. Our version, based on the original story, excluded parts that would be too violent for the students and not suited for their age, while maintaining all the aspects of Arabic heritage, along with short additions that would emphasize the pedagogical teachings of the narrative (e.g., Aladdin has to work in order to get help from the genie).

Special effort was given to include in the narration words and sounds that would be useful for teaching. As such, the language used was MSA and the linguistic expression was simple enough for students to comprehend. Thus, we took out some of the classical words that would be too difficult for students to understand.

The use of appealing images and capturing voices can capture students’ interest, while the presentation of familiar heroes using the MSA can bring students closer to the language. Short episodes can be perceived as learning packages focusing on specific goals (e.g., learning colors, fruits, tenses etc.). The story served as the continuum of the instructional method as it provided the theme for the learning activities and the educational games on the tables.

Aladdin's story was divided into 21 episodes, each one starting from where the previous part finished. The episodes were approximately of the same length, lasting around 5-7 min each. Each episode was a sequence of static images (Fig. 1), along with an audio track, in which dialog and narration were included. Actors played the roles appearing in the story, to have accurate pronunciation of the different letters according to MSA.

Fig. 1. A screen caption of an episode of the storytelling activity.

Soundboard. The soundboard belonged to the gaming activities of the new curriculum, although it is not strictly speaking a game. It is a transfer of the well-known soundboard toy for children and its purpose was to help students understand how words are pronounced in MSA and assist them in building their vocabulary. The application had three main parts: (a) the letter bar, showing all the letters of the Arabic alphabet, (b) the gallery, showing 15 different images of objects that start with the letter selected in the letter bar, and (c) the lastly touched object, showing the image the students touch last in the gallery. The activity is simple. First the students have to select a letter in the letter bar. After selecting a letter, the system selects a random set of 15 different objects that start with the selected letter. These images are retrieved from a larger pool of images. The reason for a random gallery was to cover more images and keep students' interest high: the more a student is using the application, the higher the chance to eventually see more/new images. Of course, the number of available images in the pools of each letter could differ a lot. This means that for some letters a few random galleries could cover the entire pool of images, while for others, this goal was harder to reach, and students had to keep using the application in order to see all the available images.

Next, the student has to select an image in the gallery, by touching it. Upon touching, the system plays a pre-recorded audio file representing the correct pronunciation of the word in MSA. To ensure that the pronunciation was the correct one, professional actors were hired to record the words in MSA. These were the same actors we used in the project to do voice-over of the episodes showing Aladdin's story. In general, the Aladdin's folklore story provided a continuum in the project. Most of the words used in the Soundboard activity were also in the story. In addition, we expected that having the voice of the main protagonists of the story pronouncing the words would be interesting for the students and would further enhance their engagement in this activity. Furthermore, there were many connections between the activities included in the curriculum. The images used in Soundboard were also used in other games. Thus, spending time in the Soundboard allowed students to get familiar with the vocabulary and the images they were going to see in the games to follow.

The earlier version of the Soundboard was designed to be used by 4 players at the time. For this reason, the table screen was split into four areas, with two students sitting in each long side of the table. However, the number of simultaneous images touched and the fact that the classroom provided by the school was proved to be small for the number of tables used in the project, created an incoherent noise. Because of this, a new version was developed with only one player per table (Fig. 2). To make sure that the sound would be clear for all students to hear, we added an additional set of speakers. In the end, the activity was used only on one table operated by the teacher. The students were surrounding the table, while the teacher was standing in front of it leading the first few rounds. After that, the students were taking turns in touching images and hearing the pronunciation in MSA.

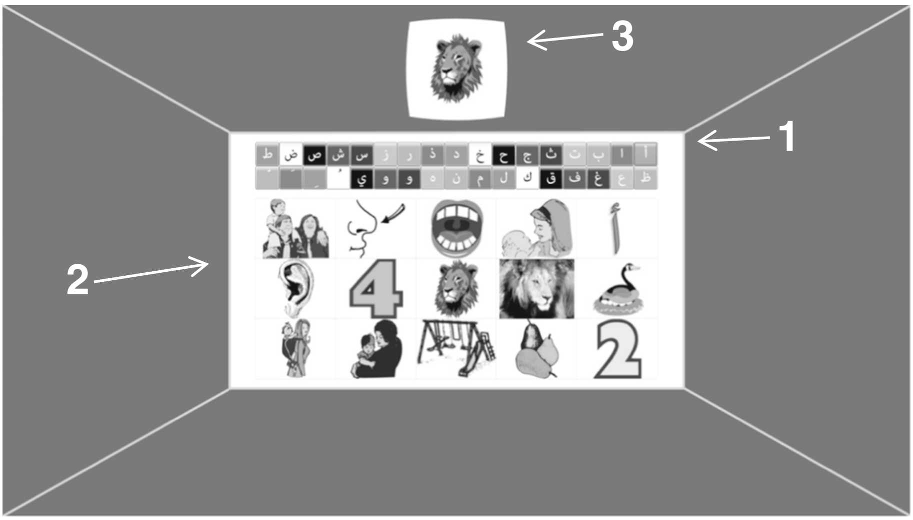

Fig. 2. Soundboard game. 1: Letter bar; 2: Gallery; 3: Current image.

Although the earlier version use multiple fixed orientations, the sound issue made it necessary to eliminate simultaneous touches and use a design approach that would allow for better control for the teacher.

Bingo. Bingo was the most played game in the study. The reason for this was that it was the first game introduced to the students and they preferred it over the other games we introduced later. The idea of the game is based on the well-known bingo game, modified, of course, for content and instructional goals. In the game, two teams of students (typically two dyads) sit on the opposite short sides of the table and play against each other trying to finish first, in order to win. In the beginning of the game, a person chooses the range of letters that are going to appear in the game, along with the duration of each round and the number of allowed mistakes per round (Fig. 3). Although students could do this on their own, we decided that it would be better for the study control, if the teacher was the one that would made these choices. This way all students in the classroom would play on the same level and on the same letters.

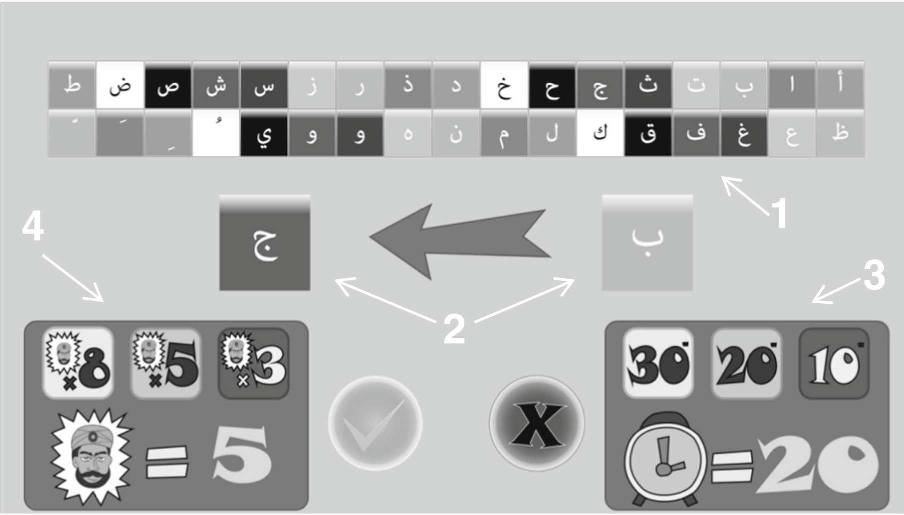

Fig. 3. Bingo game start page. 1: Letter bar; 2: Selected range of letters; 3: Seconds per round; 4: Allowed mistakes per round.

In the beginning of the game, the table screen is split in two playing areas, each one having a gallery with 40 images (Fig. 4). The galleries are populated randomly by the system that retrieves images from the pools of the selected range of letters. The randomization algorithm tries to have the same number of images for each letter. In the middle of the screen, there is a common area where the letter round and the remaining time are shown. During each round, the application picks one random letter within the selected range and displays it in the middle area. At the same time, remaining time for the round starts decreasing. The students have to touch the images in their gallery that start with the round letter. If a touched image is correct, it is replaced with Aladdin's face and remains like that for the rest of the game. In case of a mistake, the face of the Magician (i.e., Aladdin's nemesis) appears, and the object image reappears in the next round. A round ends, either when time runs out, or when both teams reach the allowed number of mistakes. The game ends, when one of the teams fills the gallery with Aladdin's face.

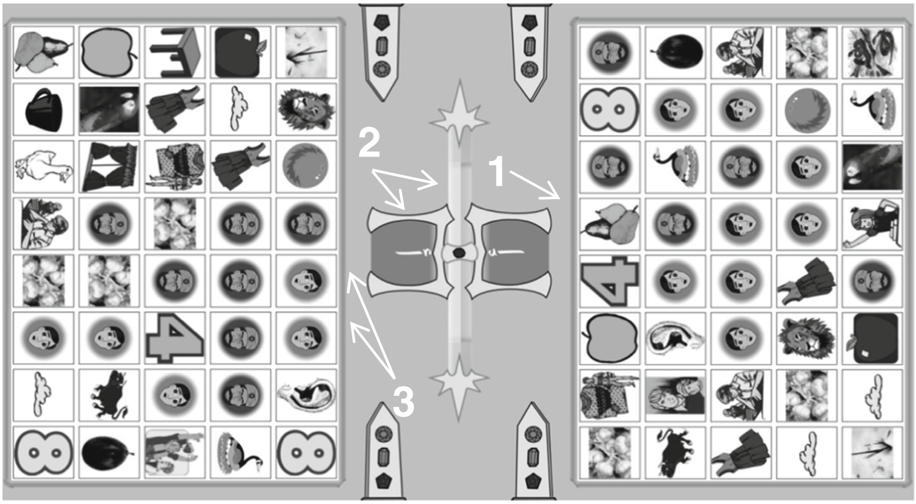

Fig. 4. Bingo game. 1: Gallery; 2: Remaining time and round letter; 3: Aladdin's and Magician's faces.

Regarding learning goals and cognitive activity, the students are expected to act in three steps. First, they need to identify the objects depicted in their galleries. Second, think or pronounce out loud the respective word in MSA, and third, decide whether the word begins with the same sound represented by the letter. Students' collaboration in teams and the factor of competition were expected to increase interaction and engagement.

At the end of each round, the system was recording the timestamp, the number of total and correct touches made, and the round letter for each team in log files.

Get3. This game is a variation of Bingo described above. The main differences between the two games are that Get3 is played individually, and there is no pressure from time limit or competitiveness. We designed this game to complement the data we were expecting from Bingo.

In Bingo, it is not possible to differentiate between the performances of each player, since it is not possible to identify each touch. In addition, the time limit in each round makes the game harder for students. Get3, on the other hand, allows the monitoring of individual performances and gives the opportunity to weaker or introvert students to take control of the game and play following their own pace. Furthermore, making the game an individual one eliminates competition, and this also lifts some of the pressure the students might feel while playing.

In terms of pedagogy, however, both games follow the same principle. The students have to match the starting sound of a word to the depicted letter. By combining the two games we were able to better understand student performance in a group and in an individual setting.

The teacher is, once again, responsible to adjust game settings and select the letter range and the goal score in the beginning of the game. Goal score is the total number of correct answers the student needs to win the game. In other words, it is a limit of how long the game will go on.

The table screen is split in four playing areas covering all available space (Fig. 5). In each area there is a small gallery of 6 images, a round letter, and indications (number and bar) showing the current score. These four areas function completely independent from each other. The gallery has always 3 correct and 3 wrong images and it is refreshed in each round.

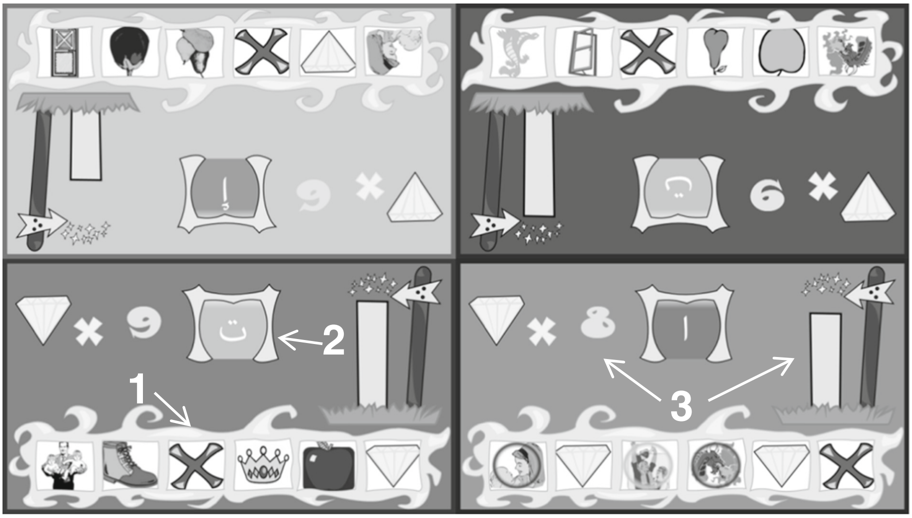

Fig. 5. Get3 game. 1: Gallery; 2: Round letter; 3: Total score and score bar.

In case of a correct touch, the image is replaced by a diamond, while, in case of a wrong answer, the image is replaced by an "X". After three images are touched, the round ends and the gallery and the selected letter are refreshed by the system. This means that in each round, the success rate of a student could vary from "0 out of 3" to "3 out of 3". The game ends for a player (but not for the whole table) when the goal score of correct answers is reached. After that, the game for the winner player starts over with the same range of letters.

The system monitors students' activity individually and records the timestamp, the round letter, and the success rate for each round. Both Bingo and Get3 were designed to play sounds on each touch (pronunciation of the words in MSA). However, because of the noise issues noted earlier in Soundboard, the sound was muted.

Pairs. This game was introduced last to the students (during the 7th week of the study), as it is the most difficult one. This is because the system does not ask for a specific letter, but students have to figure out the letters behind every image. In the Pairs application, the students have to pair images in on set to images of another set. A correct pairing refers to images that depict items that start with the same letter. So, once again, the students have to identify the items in the images and think of how these items are pronounced in MSA.

As in the previous games, the teacher has to select the range of letters and the winning score. The screen is divided into 4 areas (Fig. 6) and each student plays individually. In case of a correct pairing, the image of the respective letter appears at the bottom of the playing area, just under the paired image of the bottom set. Otherwise, an “X” appears. There is no time limit for creating the pairs and a new round starts right after all the images are correctly paired. This goes on, until the goal score is reached. Because an image cannot be paired to two images at the same time, students’ success rate in each round could be “0 out of 4”, “1 out of 4”, “2 out of 4”, and “4 out of 4” (i.e., “3 out of 4” is not possible).

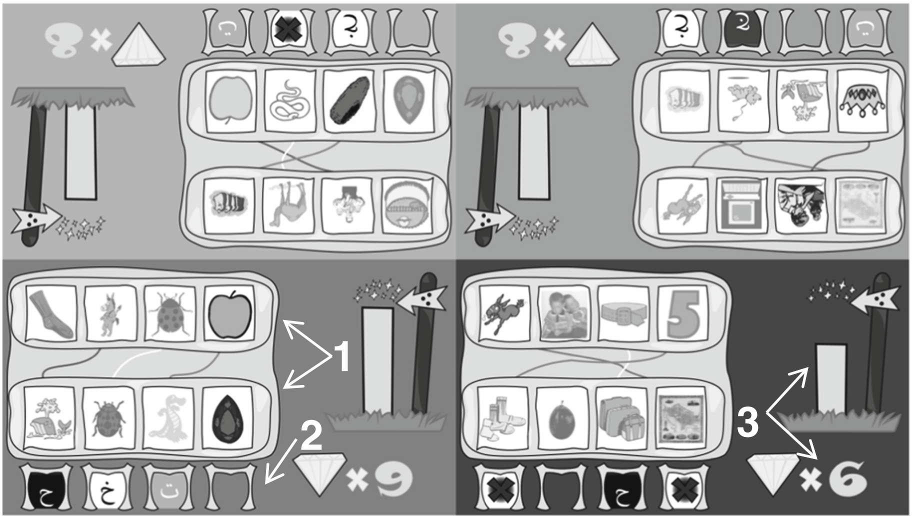

Fig. 6. Pairs game. 1: Image sets; 2: Right/wrong indicator; 3: Total score and score bar.

The system monitors the letter range, the datetime, and the number of tries per round. No individual data are recorded that would link a specific student to the recording metrics. Figure 6 shows the interface of the Pairs application.

Initially, the students did not like playing this game, because, as they said, it was hard for them. However, by the end of the 9 weeks, the students were already comfortable with the game and asked the teacher to play it. Despite this, the Pairs game is not part of the study analysis, because it was introduced late and the volume of collected data from the tables during the study period was not enough for meaningful statistical analysis. The game is presented here, in order to provide a better picture of student activity during the 9 weeks.

3.4 Procedure

Students have the Arabic Language class 4 days per week, at different hours. The class typically lasts 40 min, however, because students have to switch classrooms and since there is not always a break between classes, the actual duration of the class is usually 30–35 min.

Usually, a new letter was introduced by the teacher during the listening and discussion sessions, followed by writing activities. The games were used at the end of the class repeatedly, in order to (a) keep students' engagement and enthusiasm high, and (b) enhance retention.

Gaming sessions were usually lasting about 10 min, although, there were also sessions covering the whole class. Students played some of the games a few times per week. The class was controlled by the school teacher, with the principal investigator of the project also in the classroom to observe and take notes. The teacher was advised before class on the requirements of the new curriculum and on the planned activities to maximize the impact of the new approach. Although the principal investigator was present during the class, she was not allowed to intervene, since her role was only to observe student behavior and performance on the new curriculum.

The students were distributed to the 5 available tables in the classroom by the teacher. Although organizing students into groups of 3–4 students per table was mostly done randomly, factors such as gender, interpersonal relationships, and general student performance were often taken into account by the teacher, in order to have a balanced distribution. Group formation and students' spots were changing randomly in each class. Also, although it was not encouraged, students changing spots during a class was not forbidden either. It is important to note that students' identities were not part of the data collected by the tables or the researchers of the study.

While the number of allowed mistakes (5) and the duration of each round (20'') remained the same for most Bingo games played, the number of letters selected varied significantly to accommodate instructional needs in each class during the study period. For example, if the teacher had concerns about students' level of understanding for a specific letter, this letter might be repeated in the next lesson. This changed the schedule of the study and affected the data analysis that followed, but it was necessary, since the study had to follow a naturalistic approach.

A higher number of letters in Bingo means that, respectively, a lower number of images will appear for each letter in the gallery in the beginning of the game. This makes the game more difficult as students have fewer chances to find a correct image. On the other hand, as students proceed successfully, finding correct images and getting the number of remaining available images in the gallery (i.e., not covered by Aladdin's face) much lower, the game gets easier (up to the last round, where the only available image is also a correct one).

In contrast, the number of selected letters did not affect the difficulty level in the Get3, since the number of correct images in the gallery in each round remained constant (3 out of 6).

3.5 Data Analysis

Study findings were based on three sources: (a) on the data logs recorded by the tables during gaming activities, (b) observations made by the principal investigator in class during the lessons, and (c) on statements made by the teacher, the students', and students' parents during and after the study period in open unstructured discussions.

As mentioned earlier, each game recorded a different set of data that would allow us to understand students' behavior and performance. The study did not follow the individual progress of each student, but focused on the progress of the class as a whole. Apart from the methodological difficulties and the permissions required (by the school and parents) to follow each student separately in a naturalistic study design, another important reason for looking at the entire class was that it was impossible to match a touch on a table to a specific student, especially since, in many occasions, students changed positions during a lesson.

Regarding the observations made by the principal investigator, no audio/video recording was used, as this was not allowed in the classroom. Instead, the principal investigator attended each lesson and took notes in writing.

Finally, throughout the study, the principal investigator had several opportunities to discuss the new curriculum with the teacher, the students, and the students' parents and record their opinions.

4 Results

Students' performance analysis is based on the data gathered in the Bingo and Get3 games. Using the tabletop surface computers was easy for the students. The time for familiarization with the games was also short, since students were soon able to use the system on their own.

Table 1 shows the results from the Bingo log files, for each of the 12 total days the game was played. Students' performance varied significantly according to (a) the number of selected letters, (b) the number of letters that were new and had not been played before, and (c) their familiarization with the images of each letter through other games. As we mentioned earlier, there were in-game factors that could affect the success percentage. For example, in the beginning of a game a letter might correspond to 10 correct images in the 40-image gallery, thus giving students a 25 % chance of success. In this case, the selection of a correct image by the students might indicate that the students were indeed aware of the correct answer. As the game progresses, both the number of available correct images and the number of remaining available images in the gallery change randomly (e.g., the sequence in which the system selects the letters and the number of correct responses from the students in each round cannot be predicted). As such, the values presented in Table 1 cannot be analyzed as absolute values (in which case a 40 % success rate would mean a mediocre performance), but only by comparing them to each other.

Table 1. Bingo success percentages/per letter/per day.

Day	Alif \w h	Alif	Baa	Ta	Thaa	Jiim	Ha	Khaa	Daal	Dhaal	Raa	Zaay	Total
8/10	49.59	41.73	49.54										46.95
23/10	36.90	45.92	43.49	40.63									41.73
30/10	37.86	32.08	32.90	40.83	38.12								36.36
5/11	40.62	31.44	31.04	36.97	35.28	43.58							36.49
6/11					65.91	64.54							65.22
11/11						46.63	43.57	40.57					43.59
13/11						46.39	48.05	50.58	48.96				48.50
18/11							42.49	43.24	46.95	44.69			44.34
25/11								48.45	51.25	50.71	51.41		50.46
2/12	30.23	30.25	48.65	36.08	36.21	47.46	50.16	41.83	32.36	43.91	45.53	47.98	40.89
3/12	42.33	24.74	52.18	42.58	27.74	55.02	69.69	40.56	33.03	21.53	29.45	33.75	39.38
4/12	28.31	32.20	43.92	42.90	31.62	40.53	43.92	27.43	35.66	37.74	56.96	51.39	39.38
Avg. %	37.98	34.05	43.10	40.00	39.15	49.16	49.65	41.81	41.37	39.72	45.84	44.37	42.18
Touches	984	1001	831	754	1156	1547	928	1356	1138	786	495	156	11132
Images	362	341	327	269	580	771	391	582	491	334	224	56	4728

One characteristic example of how the number of selected letters affected students' performance is provided on the statistics on 6/11 (marked grey in the table). When we decided to use only two letters in the gallery, students' scores peaked, exceeding 65 % - much more than the total average (42 %). Regarding familiarization with the images, it seems that students had trouble differentiate between the letters "Alif with hamza" and "Alif", making more mistakes when "Alif" was selected.

Get3 was played sporadically a little after we introduced Bingo. In the beginning, not all students wanted to switch from Bingo to Get3, because they enjoyed more the collaborative nature of the first one. We asked the teacher to organize a few gaming sessions during the last week of the study, having all students playing the game. During these sessions, we gathered data for the first 8 letters (Fig. 7).

When reading the statistics, one has to have in mind the expected percentage in each occasion. As we mentioned earlier, several factors affect students' performance. Therefore, numbers in the two games should not be directly compared, but correlated. Results showed that students were able to recognize all the letters adequately, scoring once again lower in the letter "Alif" and corroborating the finding we had from analyzing Bingo data.

One more important note regarding the results is that the games used a pool of 600+ clip art images, and these images appeared thousands of times over the course of 9 weeks (e.g., 4728 just in Bingo). This extensive exposure to images and words is very important, especially if we take into account that students considered learning through these games as a reward for successfully completing other tasks, such us writing and discussion.

Regarding students' attitudes towards the new curriculum, the positive feedback we received was evident in many forms. For example, many students asked us to develop versions of the games for their tablet computers, "so that they could play at home" as they stated. The students were rushing to the "Arabic Studies" classroom, contrary to what typically happens for other classes, where students are escorted to a classroom following behind a teacher in a single-file line. Parents, teachers, and students of other classes (both from kindergarten and the co-located primary school) expressed a vivid interest in participating in similar activities, while the activities of the project recently attracted attention from Media in the region (e.g., [17, 18]).

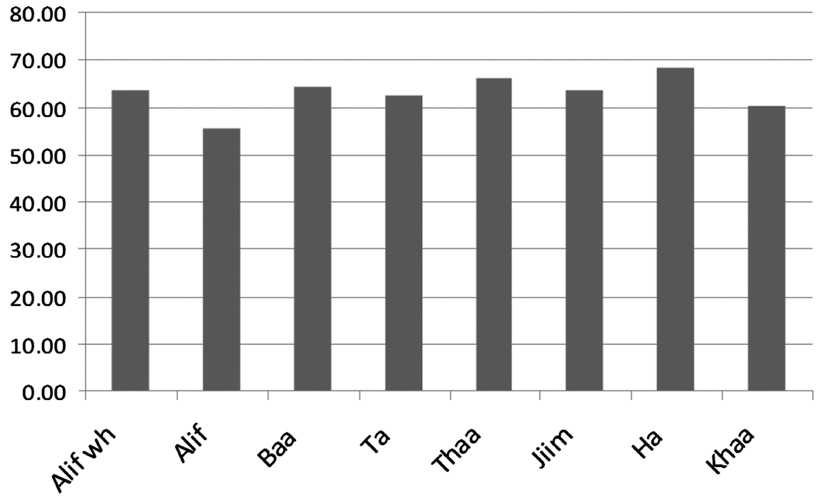

Fig. 7. Students' success percentage in Get3 game.

On the down side, some of the images used in the games were causing confusion to the students regarding the words they were depicting. The use of sound would be enough to clear this issue for the students, however, as we mentioned earlier, sounds had to be muted to avoid noise in the classroom. Finally, the number of the students in the study was easily accommodated by the number of available tables. In case of a larger group, more tables would be necessary to keep every student active. After observing students' activity during 9 weeks, be believe that it would be challenging for the teacher to manage a class in which some of the students need to wait for their turn in the tables.

5 Conclusions

The papers presented the initial analysis of the data gathered in some of the gaming activities of the Arabiyyatii project. Results showed that acceptance and engagement was very high and that there are strong indications for the effectiveness of the approach. However, improvements are also in order. First and foremost, due to the size of the classroom and the characteristics of the tables, most of the activities were lacking audio feedback. A larger space would allow us to have a better control of the sound. Second, the pool of images (and the words they depict) had to be revised and expanded – this task is now completed and the trial feedback we received is already positive on the changes made. Results showed that the students saw each image numerous times. Using more images would make the games even more interesting and would enhance students' vocabulary.

Indeed, several other games and alternative versions of the ones presented here have already been developed in the project, although they have not all tested in the classroom as part of the new curriculum. The additional games expand our initial learning goals and include recognition and production of word and small sentences. It is important to note once again, that the games are just a part of the new curriculum for MSA designed in the project. Additional multimedia and applications have also been developed and aligned to the games. A series of video episodes depicting Aladdin's folklore story in MSA, writing activities on paper and on the tables, structured and unstructured story-boarding activities, and games for cognitive tasks of higher levels (e.g., match an image to a description) are parts of the new curriculum.

Finally, it is already in our intentions to develop tablet versions of the activities. It would be interesting to see whether this approach would increase students' engagement with the material and whether the lack of a shared interface would affect students' performance and attitudes. However, it is certain that the tablet versions would allow for project deliverables to be better disseminated into society.

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References

1. Ferguson, C.: Epilogue: diglossia revisited. Southwest J. Linguist. **10**(1), 214 (1991)
2. Saiegh-Haddad, E.: Linguistic constraints on children's ability to isolate phonemes in Arabic. Appl. Psycholinguist. **28**, 605–625 (2007)
3. Behnstedt, P.: Dialect geography. In: Encyclopedia of Arabic Language and Linguistics, vol. 1, pp. 583–593. Brill, Leiden (2006)
4. Ibrahim, Z.: Myths about Arabic revisited. Al-Arabiyya **33**, 13–27 (2000)
5. Ibrahim, Z.: Lexical Separation: A Consequence of Diglossia. Cambridge University Symposium, Cambridge (2008)
6. Ibrahim, Z.: Beyond Lexical Variation in Modern Standard Arabic. Cambridge Scholars Publishing, London (2009)
7. Ibrahim, Z.: Love – fear relationship: Arab attitudes toward the Arabic Language. In: The Eminent Scholars Series: Interculturalism. Essays in honor of Professor Mohamed Enani, pp. 339–360 (2013)

8. Papadopoulos, P.M., Ibrahim, Z., Karatsolis, A.: Teaching the Arabic alphabet to kindergarteners - writing activities on paper and surface computers. In: Proceedings of the 6th International Conference on Computer Supported Education – CSEDU 2014, Barcelona, Spain (2014). doi:10.5220/0004942204330439
9. Kebritchi, M., Hirumi, A.: Examining the pedagogical foundations of modern educational computer games. Comput. Educ. **51**(4), 1729–1743 (2008)
10. Meluso, A., Zheng, M., Spires, H.A., Lester, J.: Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. Comput. Educ. **59**(2), 497–504 (2012)
11. Papastergiou, M.: Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. Comput. Educ. **52**(1), 1–12 (2009)
12. Hainey, T., Connolly, T.M., Stansfield, M., Boyle, E.A.: Evaluation of a game to teach requirements collection and analysis in software engineering at tertiary education level. Comput. Educ. **56**(1), 21–35 (2011)
13. Vangsnes, V., Økland, N.T.G., Krumsvik, R.: Computer games in pre-school settings: didactical challenges when commercial educational computer games are implemented in kindergartens. Comput. Educ. **58**(4), 1138–1148 (2012)
14. Kerne, A., Koh, E., Dworaczyk, B., Choi, H., Smith, S., Hill, R., Albea, J.: Supporting creative learning experience with compositions of image and text surrogates. In: Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications, pp. 2567–2574. AACE, Chesapeake (2006)
15. Morris, M.R., Piper, A.M., Cassanego, T., Winograd, T.: Supporting cooperative language learning: issues in interface design for an interactive table. Technical report, Stanford University (2005)
16. Piper, A.M.: Cognitive and pedagogical benefits of multimodal tabletop displays. In: Position Paper Presented at the Workshop on Shared Interfaces for Learning (2008)
17. Gulf News: Qatar uses interactive tool to teach Standard Arabic. Gulf News. http://gulfnews.com/news/gulf/qatar/qatar-uses-interactive-tool-to-teach-standard-arabic-1.1281158. Accessed 23 January 2014
18. Gulf Times: CMUQ Team Develops New Method to Teach Arabic. Gulf Times, 10 p. http://www.gulf-times.com/Mobile/Qatar/178/details/379019/CMUQ-team-develops-new-method-to-teach-Arabic. Accessed 26 January 2014

How Revealing Rankings Affects Student Attitude and Performance in a Peer Review Learning Environment

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Abstract. This paper investigates the possible benefits as well as the overall impact on the behaviour of students within a learning environment, which is based on double-blinding reviewing of freely selected peer works. Fifty-six sophomore students majoring in Informatics and Telecommunications Engineering volunteered to participate in the study. The experiment was conducted in a controlled environment, according to which students were divided into three groups of different conditions: control, usage data, usage and ranking data. No additional information was made available to students in the control condition. The students that participated in the other two conditions were provided with their usage information (logins, peer work viewed/reviewed, etc.), while members of the last group could also have access to ranking information about their positioning in their group, based on their usage data. According to our findings, students' performance between the groups were comparable, however, the Ranking group revealed differences in the resulted behavior among its members. Specifically, awareness of ranking information mostly benefited students which were relatively in favor of ranking, motivating them to further engage and perform better than the rest of the group members.

Keywords: Computer science education · Free-selection · Gamification · Motivation · Peer review

1 Introduction

This paper investigates the prospective of exploiting automatically generated ranking information in improving students' engagement and performance in the context of peer reviewing. A variety of different solutions have been proposed and evaluated by the research community for applying the peer review concept in a learning environment, aiming at the effective acquisition of domain specific knowledge, as well as of reviewing skills. It has been shown by related studies that peer reviewing can notably facilitate low level learning [1], such as introductory knowledge, besides enhancing analysis, synthesis, and evaluation that typically count as high level skills [2]. It has been reported

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that peer review can significantly stimulate higher cognitive learning processes [3] and in that manner students can be engaged in a constructive and collaborative learning activity [4]. The notable benefits offered by peer reviewing in learning have driven multiple researchers in applying such a technique in various knowledge domain. For instance, related schemes have been utilized for teaching statistics [5], second language writing [6], and computer science [7]. The latter actually constitutes the knowledge domain of this specific study.

This type of studies involve participants who play different roles, more than one most of the times. These roles may be referred in different ways, since they is no globally accepted naming scheme. For instance, in [8], students are classified as "givers" or "receiver". In [9], similar to the previous roles, students are called "assessors" or "assesses". Regardless the naming conventions, each role is typically associated with specific learning outcomes. An indication of learning outcomes differentiation depending on the participant role is found in [9], where it was shown that the quality of the provided feedback was related with students' performance in their final project. No such relationship was revealed between received feedback and final project quality. Similar findings were reported in [8]; students who performed reviews to other students' writing exhibited significantly higher performance than students who just received peer reviews.

In our study, we are focusing on a peer review setting that is based on free selection, which means that there is no central authority, instructor, or information system, that assigns specific reviews to specific students. We call this peer reviewing scheme "Free-Selection" and it has been the focus of our previous work in [10], where its potential were thoroughly study. In more detail, following this protocol, it was revealed that removing any constraints dictated by specific allocations, students tend to engage more in the reviewing activity when they are given the freedom to provide feedback on answers they choose. In such a manner, the students are exposed to a larger variety of opinions and arguments, enhancing their comprehension on the taught material. As a result, students which are allowed to follow the Free-Selection model are benefited in two ways: they are provided with the opportunity to gain deeper knowledge on the domain specific field, while they are able to significantly improve their peer review skills, compared to students which were assigned review in a random way. The promising potentials of freely selecting which peer work to review have been also demonstrated by other related studies. For instance, two related online platforms, PeerWise[1] and curriculearn[2], which are mainly focusing on facilitating students to generate their own questions, allow participants to review as many answers as they want. The recorded effect is that more reviews come from high performing students, leading to more good-quality reviews in the system [11].

Participants' engagement is proven to play a crucial role in the success of peer reviewing systems, especially when Free-Selection is applied. Towards this direction, it is important to find efficient ways of keeping students' interest at high levels, so that they remain as active as possible. A promising approach is adopting gamification, which is defined as the employment of game elements in non-game contexts [12]. For instance,

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1 http://peerwise.cs.auckland.ac.nz/.
2 http://curriculearn.dk/src/index.php.

the study findings reported in [13] reveal that when more than 1000 students where engaged in a PairWise-based activity which awarded virtual badges for achievements, their activity was notably increased since a larger quantity of work as well as feedback were submitted.

However, in our case such a gamification scheme would not be applicable. The main reason is related with the relatively limited number of participants (typically 50 to 60 students) as well as the short duration of the whole activity within a course (2 to 3 weeks), which do not allow the production of a sufficiently large volume of peer work and feedback. Hence, a decision was made to investigate some other innovative way of engaging students in such a learning activity; namely the provision of usage and ranking information. Specifically, we decided to use as usage indicators of students engagements the following metrics: the number of student logins in the employed online learning platform, the number of peer submissions read by students, and the number of reviews submitted by students. We refer to these metrics as usage information and we exploit them to enhance student engagement. Taking a step further, we decided to generate some metadata from the usage information, which potentially could be considered interesting by students, so that their engagement is even more enhanced. We actually refer to ranking information, which makes students aware of their relative position in their group regarding the individual usage metrics.

The rest of the paper is structured as follows. Section 2 describes in detail the adopted methodology for the whole experiment setup and results extraction. The collected results are presented and commented in Sect. 3. The following section concludes the paper by providing a thorough discussion on the findings as well as future directions.

2 Methodology

2.1 Participating Students

The specific activity took place in the context of a course titled “Network Planning and Design”. This is one of the core courses which is offered in the fourth semester of the 5-year study program “Informatics and Telecommunications Engineering” in a typical Greek Engineering School. The main learning outcomes of this course are related with the ability to analyze clients’ requirements, identify the specifications of the system, and design computer networks that comply with the above. Hence, the students taking this course need to have an adequately strong technical profile. The study was conducted with students who volunteered to participate in this learning activity and get a bonus grade for that part of the course that was associated with lab sessions. Finally, 56 students volunteered to take part and complete the activity. Participating students were randomly assigned to three groups with different treatment according to the conditions of the conducted study. Specifically, the groups were formed as follows:

Control: 18 students (11 male, 7 female)
Usage: 20 students (11 male, 9 female)
Ranking: 18 students (10 male, 8 female)

This different treatment that students received based on the above classification was exclusively related with the information that was made available to them. The tasks that had to be completed in the activity context were actually identical for all students. Specifically, no extra information related with the learning activity, either usage or ranking, was provided to the students belonging to the Control group. On the other hand, students in the Usage group received information about their usage metrics, whereas Ranking group students were provided with extra information about their ranking within their group revealing indications related to their individual progress.

2.2 Instruction Domain

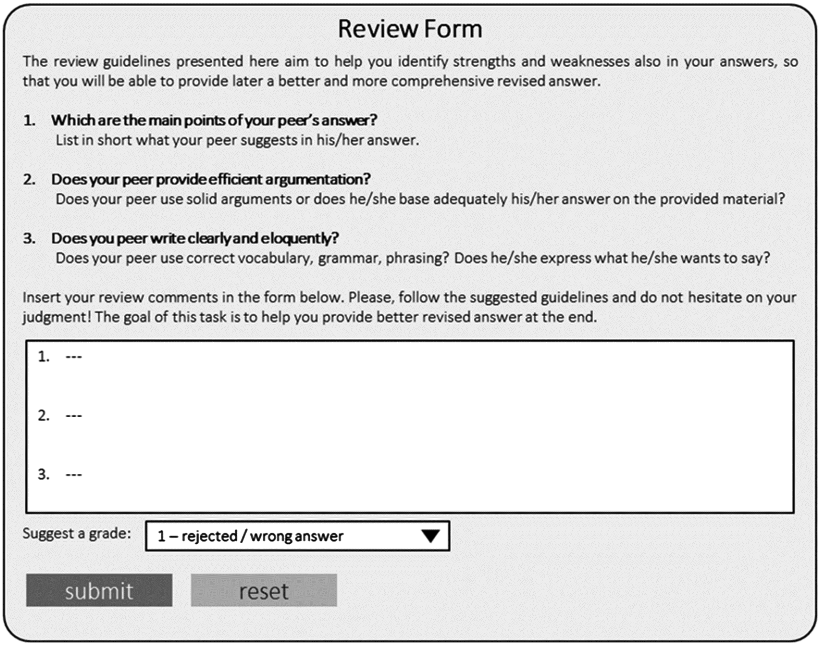
The domain of instruction was "Network Planning and Design", which is a typical ill-structured domain characterized by complexity and irregularity. Any Network Planning and Design project involves a number of designing decisions that are mainly based on the subjective analysis of clients requirements. In fact, the engineer is expected to solve an ill-defined problem described by the client. In order to accomplish this task, the designer needs to take numerous factors into account, which are also not fixed and are mainly related with technical details and cost constraints. In particular, a loosely describe process needs to be followed in order to proposed an appropriate network topology which combines suitable network components in a manner that requirements are adequately met. The nature of this type of project outcomes is effectively described in [14], where it is stated that the results of the followed process are actually derived by analyzing the requirements set by the client, while balancing the adopted technology against cost constraints. For these reasons, an efficient way of teaching NP&D would involve studying of realistic situations. In such a manner, students could significantly benefit by learning from existing experience and they would be provided with the opportunity to build their own technical profile. As it is supported by authors in [15], project-based instruction methods could notably benefit Computer Engineering students and help them learn to handle real world complex problems.

2.3 Material

The Online Learning Platform. This study utilizes a learning environment that was designed as a generic online platform able to support activities based on peer reviews. The eCASE platform is a custom made tool that facilitated both individual and collaborative learning in ill-structured domains of knowledge. Employing a custom-made learning environment has the obvious advantage of allowing modifications and adjustments in order to match the required conditions of the specific research activity. The suitability of eCASE for such studies has been already proven in previously published work investigating different aspects of case-based learning [16], of CSCL collaboration models [17], and of peer reviewing schemes [10].

The material held by the system is organized into two main categories: scenarios and cases. Each scenario constitutes the description of a realistic NP&D problem that students are required to solve. Moreover, each scenario focuses on a number of characteristics and factors that affect designing decisions. Students are able to enhance their understanding and acquire the knowledge required to suggest some solution for a scenario by carefully studying a number of cases that are related with it. Cases are descriptions of similar realistic NP&D problems, along with proposed solutions, which are accompanied by detailed justification. All cases that are associated with a specific case focus on the same domain factors, such as performance requirements, expected traffic type and network user profile, network expansion requirements, and financial limitations. The students are able to produce their own proposed network design as a solution for each scenario after consulting the corresponding scenarios. It is also noted that the presented scenarios and cases try to partially build on the knowledge acquired by studying the previous scenarios and cases. In that manner, the second scenario is more advanced and complex than the first one, while the third scenario is the most advanced and complex of all three.

Apart from the material presented to the students, the online platform is designed to fully support the reviewing process and provide students with usage information depending on the group they belong to. In more detail, the systems made available a review form that was used by students to provide feedback to their peers. As shown in Fig. 1, the review form provided some guidance to the students, focusing on three points, so that feedback fulfills some basic requirements. The system was also responsible for keeping all types of deliverables, for monitoring students' progress, and for controlling access. Although building our own platform definitely gave us increased flexibility, we do not consider the system as part of the analysis for this paper.



Review Form

The review guidelines presented here aim to help you identify strengths and weaknesses also in your answers, so that you will be able to provide later a better and more comprehensive revised answer.

1. **Which are the main points of your peer's answer?**
   List in short what your peer suggests in his/her answer.
2. **Does your peer provide efficient argumentation?**
   Does your peer use solid arguments or does he/she base adequately his/her answer on the provided material?
3. **Does you peer write clearly and eloquently?**
   Does your peer use correct vocabulary, grammar, phrasing? Does he/she express what he/she wants to say?

Insert your review comments in the form below. Please, follow the suggested guidelines and do not hesitate on your judgment! The goal of this task is to help you provide better revised answer at the end.

1. ---
2. ---
3. ---

Suggest a grade: 1 – rejected / wrong answer

submit reset

Fig. 1. Review form.

Tests. The study included two test for the students. One given before starting the activity (i.e., the pre-test) and one right after the completion of the activity (i.e., the post-test). The purpose of the former test was to create a reference point for analysis by noting where students were standing regarding prior knowledge on the domain of instruction. Six open-ended questions were used for that purpose (such as "How does knowledge on the end-user profile of a network affect its architecture?"). The pre-test aimed at revealing knowledge acquired through the learning activity. It included 3 open-ended questions (such as "What kind of changes may occur in the architecture of a network, when the expansion requirements are increased?").

Questionnaire. Students were asked to complete an online question after the end of the study. Our purpose was to collect their opinions on a variety of activity-related aspects. For instance, students commented on the following: their reviewers' identity, the amount of time they devoted in the learning environment during the different activity phases, and the impact of usage/ranking information. A number of both open and closed-type questions were used for building the attitude questionnaire.

2.4 Design

This work adopts a widely employed study design approach which dictates comparison of participants' performance in all groups before treatment and after treatment. The independent variables of our experiments are the usage and ranking information. The dependent variables were related with students' performance in the learning environment, the pre-test, the post-test, and their recorded opinions in the attitude questionnaire. The whole activity was divided in 6 non-overlapping phases: Pre-test, Study, Review, Revise, Post-test, and Questionnaire.

2.5 Procedure

The duration and the order of the 6 phases are graphically depicted in Fig. 2. The study started with the Pre-test that took place in class. Right after it we had the Study phase, which lasted for 1 week. During that phase the students were able to study the online material; they went through the past cases and proposed network designs for the corresponding scenarios. Specifically, each one of the 3 scenarios was made available to students along with the associated 2 cases for each scenario. After finishing reading the cases, they were requested to write a description of a network as solution to the scenario and then proceed to the next one.

Fig. 2. Activity phases.

The following phase was about reviewing peers' work and lasted 4 days. During the Review phase students were providing feedback to their classmates through eCASE. Since the Free-Selection protocol was adopted, students were free to choose and review any peer work that belonged to the same group. The peer-review process was double-blinded, without any limitation on the number of reviews to provide. However, they were obliged to complete at least one review per scenario. To help them choose, the online platform arranged the start of peers' answers (including in approximate the first 150 words) into a grid, as shown in Fig. 3. The answers were presented in random order, with an icon indicating if the answer is already read (eye) and/or reviewed (green bullet) by the specific student.

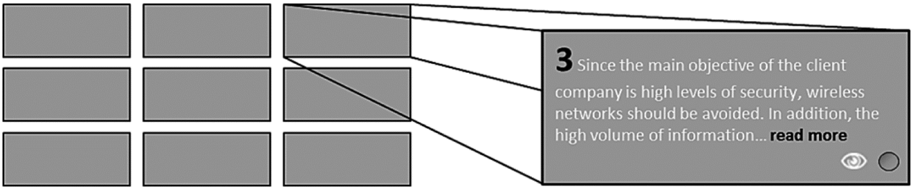


Fig. 3. An example illustration of the answer grid, where peer answer no. 3 has been read and reviewed by the student.

The user was able to read the whole answer and then review it by clicking on "read more". A review form (Fig. 1) was the shown to be filled by the student, providing some guidance by emphasizing on three main aspects of the work:

1. The basic points of the work under review.
2. The quality of the arguments provided by the author.
3. The phrasing and expression quality, as well as the overall answer clarity.

The user performing a review was also requested to suggest a grade, based on the comments he provided. The available 5-step options following the Likert scale are shown below:

1. Rejected/Wrong answer
2. Major revisions needed
3. Minor revisions needed
4. Acceptable answer
5. Very good answer

The three student groups, Control, Usage, and Ranking, received different treatment only in terms of the extra information that was presented to them. Apart from that, the actual tasks they had to complete within the activity were identical for all. In that manner, we were able to figure out the impact of the additional information. The main idea was enhancing student engagement, so in that sense we opted for metrics that were directly related with enforcing activity. More specifically, the three usage metrics that we selected aim at motivating students to: (a) visit the online platform more often, (b) collect more points of view by reading what others answered, and (c) provide more reviews to peers' work. Accordingly, the three corresponding metrics that were made available to the students of the Usage and Ranking groups were the following:

The number of logins in the online learning platform.
The total read count of different peers' work.
The total reviews they provided to different peers' work.

It is worth mentioning that these usage metrics did not provide any additional information, since it is apparent that a user that would keep track of her activity could come up with those values in a manual way. Of course, the students were not requested to perform such a task, and it clearly is much more convenient to have the metrics automatically available by the system. Regarding the extra information that was provided exclusively to the members of the Ranking group, it was revealing relative position to the group's average and as such could not be calculated by the students themselves without the system. Ranking information was presented to the users via chromatic coding to show the quartile according to the ranking (1st: green; 2nd: yellow; 3rd: orange; 4th: red).

Next, the Revise phase started right after the completion of the reviews and allowed students to consider revising their work taking into account the reviews that were now accessible. This phase lasted 3 days to allow students with enough time to read the received comments and potentially improve the network designs they proposed. They were also able to provide some feedback about the reviews they received. In case a student happened not to receive any feedback, the online platform provided her with a self-review form, before proceeding to any revisions of the initial answer. This form guided students on properly comparing their answers against others' approaches, by requesting the following:

1. List their own network components.
2. Justify choosing each component.
3. Grade themselves.
4. Identify and argue for needed revisions.

The Revise phase was considered completed by the system as soon as a student submitted the final version of her answer for each one of the three scenarios, regardless to whether she had eventually performed revisions or not.

It is already noted earlier that ın the beginning of the Revision phase, one more metric was available to the Usage and Ranking groups, the average scores received from peers, along with the number of received reviews. This was the one metric that students could not affect.

The information that was shown to each group, along with some example-values, are presented in Table 1. The 2-week activity was completed with the in-class Post-test, which was then followed by the attitudes questionnaire.

Table 1. Example of usage/ranking information shown to students in each group.

	Control	Usage	Ranking		
Metric		Value	Value	Mean	Ranking
Number of logins in the environment	<no data>	12	15	9.4	4th
Peer work viewed in total		9	6	13.9	17th
Peer work reviewed in total		5	5	4.5	6th
Score received from peers (no of peers)		3.8 (5)	3.1 (4)	3.4	11th

3 Results

To avoid biases, students' answer sheets of the pre and post-test were mixed and blindly assessed by two raters that followed predefined grading instructions. The statistical analysis performed on the collected results chose a level of significance at .05. The parametric test assumptions were investigated before proceeding with any actual statistical tests. It was found that none of the assumptions were violated. On that ground, we first examined the reliability between the two raters' marks. The computed two-way random average measures (absolute agreement) intraclass correlation coefficient (ICC) revealed high level of agreement (>0.8 for each variable) indicating high inter-rater reliability.

3.1 Pre-test and Post-test Results

Students' scores in both written testes are presented in Table 2. As expected, pre-test scores were notably low, since students were novice in the specific domain of knowledge. Moreover, it was shown via analysis of variance (ANOVA) that in all three groups students achieved comparable scores, indicating that the distribution of students in the three groups was indeed random. In order to compare student performance after the completion of the activity in all groups, one-way analysis of covariance (ANCOVA) was performed, employing as covariate the pre-test score. The respective results showed again no statistical differences ($p > .05$) between the three groups.

Table 2. Scores in pre-test and post-test.

	Control			Usage			Ranking		
(scale: 0–10)	M	SD	n	M	SD	n	M	SD	n
Pre-test	2.11	(0.98)	18	1.98	(1.01)	20	2.02	(1.09)	18
Post-test	8.17	(1.01)	18	8.10	(0.96)	20	8.11	(0.93)	18

3.2 Performance in Learning Environment

Apart from the pre-test and the post-test, the two raters also marked students' work in the online learning platform. Table 3 reveals statistics about the 3-scenarios average scores that students' initial and revised answers received from the two raters. The Likert scale used was the same with the one used by reviewers (1: Rejected/Wrong answer; 2: Major revisions needed; 3: Minor revisions needed; 4: Acceptable answer; 5: Very good answer).

Table 3. Scores in learning environment.

	Control			Usage			Ranking		
(scale: 1–5)	M	SD	n	M	SD	n	M	SD	n
Initial	2.94	(0.58)	18	3.12	(0.75)	20	2.80	(0.77)	18
Revised	3.44	(0.67)	18	3.64	(0.58)	20	3.49	(0.77)	18

Paired-samples t-test results between the initial and the revised score for each group showed significant statistical difference ($p < .05$) in all three groups. This indicates that students were benefited from the peer reviewing process. However, similarly to the writing tests score, the comparison between the three groups does not reveal any statistically significant different ($p > .05$). This finding came from the one-way ANOVA test that was applied on the two variables (initial score and revised score). The inference is that presenting usage/ranking information had no significant impact on students' performance in the learning environment. Similar conclusion can be drawn from the usage metrics presented in Table 4. As with the learning environment performance, the comparison between the three groups revealed no significant difference.

Table 4. Values of usage metrics.

	Control			Usage			Ranking		
	M	SD	n	M	SD	n	M	SD	n
Logins	30.29	(12.90)	18	28.73	(14.02)	20	28.06	(14.44)	18
Views	12.54	(9.26)	18	11.47	(10.57)	20	14.31	(7.69)	18
Reviews	4.31	(1.02)	18	4.18	(1.21)	20	4.21	(0.93)	18
Peer Score	3.61	(0.89)	18	3.56	(0.91)	20	3.51	(1.10)	18

3.3 Questionnaire Outcomes

Students' responses to the most significant questions included in the attitude questionnaire are summarized in Table 5. Looking one by one at the results for each one of the five questions, important conclusions can be made. First of all, based on Q1, students in general did not care to know who reviewed their work. Actually, only 4 out of 56 expressed the interest to learn their reviewers' identity; three just for curiosity and one because of strong objections to the received review.

The second and third questions are about the time students spent in the activity. In fact, we have been keeping track of time students were logged in the system, in order to have an indication of their involvement. However, in many cases, the logged data may not correspond sufficiently to the actual activity duration. For instance, a logged user does not necessarily mean an active one. For that reason, we decided to contrast the logged data to students' responses. Specifically, students from all groups reported comparable time spent during the first week ($p > .05$), according to responses in Q2. On the other hand, students belonging to the Ranking group spent significantly more time ($F(2,53) = 3.66$, $p = .03$) in the online platform during the second week, according to responses in Q3. It is highly notable that students spent much more time during the first week than during the second week. However, that was expected, since the first week involves studying for the first time all the material and writing all original answers.

Table 5. Summary of questionnaire responses.

	Control	Usage	Ranking
	(n = 18)	(n = 20)	(n = 18)
	M (SD)	M (SD)	M (SD)
Q1. Would you like to know the identity of your peers that reviewed your answers? (1: No; 5: Yes)	1.70 (0.80)	1.95 (1.16)	1.84 (1.30)
Q2. How many hours did you spend approximately in the activity during the first week (Study phase)? (in hours)	10.08 (3.09)	10.12 (3.80)	9.59 (3.94)
Q3. How many hours did you spend approximately in the activity during the second week (Review and Revise phases)? (in hours)	2.48 (1.40)	2.33 (1.01)	3.31 (1.13)*
Q4. Would you characterize the usage information presented during the second week as useful or useless? (1: Useless; 5: Useful)	n.a.	4.33 (1.06)	4.26 (0.81)
Q5. Would you characterize the ranking information presented during the second week as useful or useless? (1: Useless; 5: Useful)	n.a.	n.a.	3.53 (1.07)

This activity is definitely more time consuming than reviewing and revising answers.

Responses to question Q4 showed that students of the Usage and Ranking groups had a positive opinion for the usage information presented to them during the second week. In fact, only 3 students claimed that they did not pay any attention and did not find the information important. A follow-up open-ended question about the way usage metrics helped students revealed that the provided information was mostly considered “nice” and “interesting” rather than “useful”. In general, almost all students agreed that being aware of usage data did not really have an impact on the way they studied or on the material comprehension.

However, Ranking group students had different opinions about the presented ranking information. According to the responses provided in Q5, most of the students (n = 10) were positive (4: Rather Useful; 5: Useful), whereas 4 of the group members claimed that ranking information was not really useful. The students that had a positive opinion, argued that knowing their ranking motivated them to improve their performance. For instance, a student positioned in the top quartile stated: “I liked knowing my ranking in the group and it was reassuring knowing that my peers graded my answers that high.”

3.4 Elaborating on the Ranking Group

In this subsection, we further analyze students’ opinions about ranking information, since their responses to Q5 revealed two different standings. A closer look on how students behaved in the Ranking group showed three main patterns. Performing a case-by-case analysis on the number of logins and the reviews performed by each student, we saw that there were students that tried to improve their rankings and maintain a high position, students whose ranking were relatively stable, and students whose ranking were dropping steadily as the activity progressed.

Figure 4 shows three distinctive cases illustrating the above. Day 8 is the first day of the Review phase in the study. Students’ rankings were recorded by the system before that date, but became available for the first time to them on that date.

During the 4 days of the Review phase, Student A jumps in rankings from position 10 to position 2, with her position improving each day. This means that this student had increasingly more logins in the system than the other students. On the other hand, Student B’s position remains relatively unchanged near the middle of the group population. Finally, Student C had enough logins during the Study phase of the activity to be placed on the 7th place in the beginning of the Review phase. However, there is a constant decline in visiting the system after that.

Similar analysis on the other metrics of the study showed that students reacted differently to the ranking information. This finding, along with the explicitly stated differentiation of students in Q5 made us look further into the performance of the Ranking group.

For this reason, we split the Ranking group in two: (a) the InFavor subgroup that included 10 students who were positive towards ranking information, and (b) the Indifferent subgroup that included the other 8 students who had a neutral or negative opinion against ranking information. We focused on performance metrics, which are summarized in Table 6.

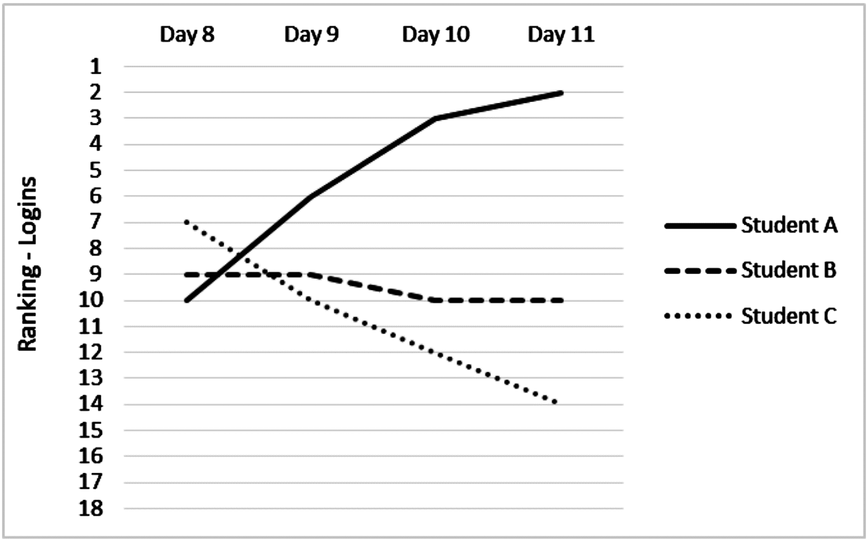


Fig. 4. Login rankings of three students of the ranking group during the review phase.

Table 6. Performance of the two ranking subgroups.

	Logins*		Views*		Reviews		Peer Score*		Post-test*	
	M	SD	M	SD	M	SD	M	SD	M	SD
Indifferent (n = 8)	21.88	(5.17)	10.50	(6.58)	4.00	(1.00)	2.89	(0.93)	7.53	(0.78)
InFavor (n = 10)	33.78	(4.43)	18.22	(7.46)	4.45	(1.13)	3.83	(0.67)	8.59	(1.02)

We performed a t-test analysis to compare the performance of the two sub-groups. The results indicated significant difference between the subgroups in the number of logins ($t[16] = 5.26$, $p = .00$), the number of peer work read ($t[16] = 2.29$, $p = .03$), the score they received from peers on the initial answers ($t[16] = 2.49$, $p = .02$), and the scores in the written post-test ($t[16] = 2.42$, $p = .02$). There was no significant difference, however, in the number of submitted reviews ($p > .05$). The inference that can be made at this point is that students belonging in the InFavor subgroup were usually representing the top 10 positions in the Ranking group, in terms of performance.

4 Discussion

The idea of using ranking information as a means for motivating students requires extra attention, because it can significantly affect the main direction of the whole learning activity. Typically, different schemes adopt badges, reputation scores, achievements, and rankings to increase student engagement and performance (for instance, students may be encouraged to correctly answer a number of questions in order to receive some badge). It must be highlighted though that this type of treatment does not alternate the settings of the learning activity. This means that receiving badges or any recognition among peers does not change the way the student is acting in the learning environment. This specific aspect actually differentiates this type of rewarding to typical loyalty programs adopted by many companies (e.g. extra discounts for using the company card). Although students do not receive tangible benefits like customers do, it is important that increasing reputation can act as an intrinsic motive for further engagement. However, the specific effect on each student greatly depends on her profile and the way she reacts to this type of stimuli.

The different attitudes towards ranking information became evident from the corresponding question (Q5) in the attitude questionnaire. Our findings showed that students who responded positively, were more active in the learning environment and generally exhibited better performance during the study and at the post-test. The fact that they achieved better scores even before viewing ranking information, specifically higher marks for their initial answers, indicates that these were students who reached higher levels of understanding the domain of knowledge. Although the related statistical analysis results strongly support this argument by revealing significant differences, we report it with caution, since the studied population (students in the two subgroups of the Ranking group) is small for safe conclusions.

Usage information, on the other hand, was widely accepted from students in the Usage and Ranking groups. Despite the positive attitude, just being aware of the absolute metric value does not motivate behavior changes or improved performance. In fact, usage information was considered "nice" by the students, but not enough to make an impact. Apparently, a student was not able to assess a usage metric value about her performance without a reference point or any indication of the group behavior. However, it must be noted that this type of information could probably prove more useful in a longer activity, where a student can track her progress by using previous values for comparison.

While considering all the data that became available to us after the completion of the study, we were able to identify more details about the effect of ranking information. A case-by-case analysis revealed different attitudes even within the Ranking subgroups. For instance, there were students who took into account their rankings throughout the whole duration of the activity, while others considered them only at the beginning. An interesting case is that of two students of the Indifferent subgroup, who expressed negatively about the ranking information, arguing that they disliked it because it increased competition between the students, so they eventually ignored it. What is even more interesting is that system logs showed that both students had post-test scores above the average, while they held one of the top 10 positions in multiple usage metrics. On the other side, a student from the InFavor subgroup focused exclusively on keeping her rankings as high as possible during the whole activity. In fact, she managed to do so for most of the metrics (Logins: 66; Views: 43; Reviews: 3; Peer Score: 3.53; Post-test: 7.80). It is worth mentioning that the specific student only submitted the minimum number of reviews and scored significantly below the average in her initial answers and the post-test, despite the fact that she had visited eCASE twice the times of her subgroup average and viewed (or at least visited) 43 out of the total 51 answers of her peers. These findings lead us to the conclusion that the student missed the aim of the learning activity (acquisition of domain knowledge and reviewing skills development) and was accidentally misguided to a continuous chase of reputation points. Moreover, the short activity periods that the system recorded in its logs show that this specific student did not really engage into the learning activity, but rather she participated superficially. This type of attitude towards the learning scheme actually matches the definition of "gaming the system" [18], according to which a participant tries to succeed by actively exploiting the properties of a system, rather than reaching learning goals.

The three cases discussed above constitute extreme examples for our study. However, they make clear that depending on the underlying conditions the use of ranking information might sometimes have the opposite effect of the one expected by the instructor. Adding to these three cases, some students mentioned that low ranking would motivate them to improve their performance in order to occupy a higher relative position. Furthermore, it was also reported by students that a high position was reassuring, actually limiting incentives from improvement. One way or another, it is obvious that the point of view greatly depends on the fact that many students have a very subjective opinion about the quality of their work, which is quite different from the raters' view. Hence, solely relying on ranking information can potentially prove a misleading factor.

Conclusively, the use of ranking information as engagement enhancer for the students could significantly benefit them, particularly in cases that students have a positive attitude towards the revelation of this type of information. In such cases, the intrinsic motivation of students is strengthened. Nevertheless, it is important to closely monitor students' behavior and reactions during the learning activity, in order to identify cases where ranking information could cause the opposite effect resulting in disengaging.

References

1. Turner, S., Pérez-Quiñones, M.A., Edwards, S., Chase, J.: Peer review in CS2: conceptual learning. In: Proceedings of SIGCSE 2010, Milwaukee, Wisconsin, USA, 10–13 March 2010
2. Anderson, L.W., Krathwohl, D.R. (eds.): A Taxonomy for Learning, Teaching, and Assessing: a Revision of Bloom's Taxonomy of Educational Objectives. Longman, NY (2001)
3. Scardamalia, M., Bereiter, C.: Computer support for knowledge-building communities. J. Learn. Sci. **3**(3), 265–283 (1994)
4. McConnell, J.: Active and Cooperative Learning. Analysis of Algorithms: An Active Learning Approach. Jones & Bartlett Pub, Burlington (2001)
5. Ashley, K.D., Goldin, I.M.: Peering inside peer review with bayesian models. In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS, vol. 6738, pp. 90–97. Springer, Heidelberg (2011)
6. Hansen, J., Liu, J.: Guiding principles for effective peer response. ELT J. **59**, 31–38 (2005)
7. Liou, H.C., Peng, Z.Y.: Training effects on computer-mediated peer review. System **37**, 514–525 (2009)
8. Lundstrom, K., Baker, W.: To give is better than to receive: the benefits of peer review to the reviewer's own writing. J. Second Lang. Writ. **18**, 30–43 (2009)

9. Li, L., Liu, X., Steckelberg, A.L.: Assessor or assessee: how student learning improves by giving and receiving peer feedback. Br. J. Educ. Technol. **41**(3), 525–536 (2010)
10. Papadopoulos, P.M., Lagkas, T.D., Demetriadis, S.N.: How to improve the peer review method: free-selection vs assigned-pair protocol evaluated in a computer networking course. Comput. Educ. **59**, 182–195 (2012). Elsevier
11. Luxton-Reilly, A.: A systematic review of tools that support peer assessment. Comput. Sci. Educ. **19**(4), 209–232 (2009)
12. Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From game design elements to gamefulness: defining "gamification". In: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments (MindTrek 2011), pp. 9–15. ACM, New York (2011)
13. Denny, P.: The effect of virtual achievements on student engagement. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM (2013)
14. Norris, M., Pretty, S.: Designing the Total Area Network. Wiley, New York (2000)
15. Martinez-Mones, A., Gomez-Sanchez, E., Dimitriadis, Y.A., Jorrin-Abellan, I.M., Rubia-Avi, B., Vega-Gorgojo, G.: Multiple case studies to enhance project-based learning in a computer architecture course. IEEE Trans. Educ. **48**(3), 482–489 (2005)
16. Demetriadis, S.N., Papadopoulos, P.M., Stamelos, I.G., Fischer, F.: The effect of scaffolding students' context-generating cognitive activity in technology-enhanced case-based learning. Comput. Educ. **51**(2), 939–954 (2008). Elsevier
17. Papadopoulos, P.M., Demetriadis, S.N., Stamelos, I.G.: Analyzing the role of students' self-organization in scripted collaboration: a case study. In: Proceedings of the 8th International Conference on Computer Supported Collaborative Learning – CSCL 2009. pp. 487–496. ISLS, Rhodes, Greece (2009)
18. Baker, R., Walonoski, J., Heffernan, N., Roll, I., Corbett, A., Koedinger, K.: Why students engage in "gaming the system" behavior in interactive learning environments. J. Interact. Learn. Res. **19**(2), 185–224 (2008). Chesapeake, AACE, VA

Quality in Distance Learning Courses: A Longitudinal Survey of Teacher Training in Federal Programs

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Abstract. This research developed throughout 2006 to 2013 has prospected nine thousand students about critical achievements in distance learning courses. We had 5,892 answers to the applied questionnaire where students were teachers in an in-service training course. The constructs to build the questionnaire were chosen from the literature and validated for a specialist panel. These constructs were: teaching materials, pedagogical mediation, virtual learning environment, methodology, student academic and technical support. Nevertheless, qualitative assessment showed some other aspects mentioned by the respondents such as teaching strategies, objectives, curricula content and their dynamics indicating that a distance learning mode course requires an active pedagogical mediation and the teaching-learning design must encourage collaboration. A content analysis was conducted revealing a whole world interpretation by a given community.

Keywords: Quality assurance · Course evaluation · Teacher training · Distance education

1 Introduction

Major investments were made in undergraduate and post-graduation courses offered in the distance learning mode by governmental and private institutions increasing considerably the number of enrollments and courses in recent years. This rapid growth, especially when means of carrying out government goals with regard to increasing the number of enrollments in higher education, imposes the need to rethink the indicators used to evaluate the quality of distance courses.

The initial argument of this work is to evince authors that deal with the construction of the concept of quality in higher education on the assumption that education is a right and the government should provide it for society. We believe in the consolidation of national identity and the social and economic inclusion of marginalized groups. This principle of education guides a concept of quality articulated with the paradigm of relevance and social responsibility and is based on two other principles:

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democratization and the reconceptualization of the role of higher education institutions in the Network Society [1].

From this axis, we seek a reflection on the quality concept that has anchored the practices and perceptions of distance education. We consider three aspects: educational-learning, tutorial and technical-structural.

2 Distance Education: What Are We Talking About Quality?

The diversity of views and the inexorable conceptual subjectivity of the term quality in education is not exempt from the constant referencing in speeches about educational policies and institutional practices [2]. The chameleon effect of the term "quality" when applied to higher education stems from the complexity of possible relationships that education may have in their technical, scientific, political, cultural and economic dimensions. Thus, talking about quality is always to seek reference "quality of what?", "which social-historical moment?", "defined by whom?" In this section, we will seek to bring some of these reflections.

Generically, the term quality can be defined as the satisfaction of a dynamic in which the effectiveness of the results is equivalent to the first placed expectations and, therefore, the processes should demonstrate efficiency.

The issue of quality in brazilian higher education was studied by [3] from qualitative indicators anchored in the socio-cultural and economic context, such as the effectiveness (achieve the basic functions of higher education and integral formation of individuals and society), relevance (development of the socio-cultural and economic areas of the country), fairness (opportunity to access and retention for all people from different regions and social classes) and diversity (meet the various demands and needs of education and training).

These qualitative indicators are related to the search for solutions to major national problems such as inequality and social exclusion, insufficient economic growth and qualitative and quantitatively deficient education systems. In this sense, the quality of higher education must be analyzed from the paradigm of relevance and social responsibility showing the ability to propose ways and coping alternatives of the national problems.

Debates about quality in higher education are centralized in the paradigm of relevance and social responsibility that clashes with the interests and expectations of another paradigm, derived from the neoliberal policy [2, 3]. The paradigms of neoliberal policies and the relevance and social responsibility evoke three central themes on the agenda of higher education around the world: democratization, reconceptualization of higher education institutions and the quality.

The emerging paradigm of neoliberal policy considers that quality aims to be objective and universal, valuing the scientific rigor and the quantitative and measurable aspects. Criteria are identified with terms and economic schemes such as development indices, profitability, cost-benefit calculations, efficiency, innovation linked to economic income, growth in enrollment, teacher-student ratio, output indicators, expansion systems, measuring the performance of institutions, student performance, diversification of funding sources, among others [4]. According to [3] the neoliberal paradigm opens an economistic vision of quality in higher education, in which the main mission of the universities must be the economic growth and the preparation of individuals for the labor market. Therefore, institutions should be organized efficiently and effectively so that their objectives are achieved quickly and at less cost, demonstrating an instrumental and productivist view of education. According to the author, the economic view of quality in higher education is shared by the private sector, by some governments and multilateral organizations identified with the minimum state policy and fiscal adjustment.

The paradigm of relevance and social responsibility, though not despise many of the aspects mentioned above, perceives a different light, valuing the social and political realities of the institutions and education systems, the qualitative dimensions inserting the higher education in national and regional strategies for consolidating democracy [4]. The principle of this paradigm is that the mission of higher education goes beyond economic promotion and is also a way to promote cultural, social, political and scientific development. Thus, higher education quality must be able to promote equity and social cohesion, increasing the possibilities for access and retention.

It is in the 2000s that Brazil becomes a nation in transition to the so-called Network Society [5] and, therefore, the labor market has demanded new training requirements and training at a higher level in order to become the most dynamic and productive economy. Given this situation, it was necessary to increase the number of enrollments in public universities, which represented a challenge to the state, given that the public higher education institutions are located in urban areas, concentrating the supply of places around 30 % of the municipalities [5].

As for teacher training, it was found that the training of teachers in the early years of the 2000s, was a sticking point in the implementation of public policies. The association of teacher education level with the quality of basic education was sufficient to realize the urgency of drawing initial training policies for those teachers already working or were working in basic education [6].

The democratization of higher education initially demanded a basic education that boosts the expansion of higher education and teacher education represented a key part in this process, so that teacher training has become a determining factor in the quality offered in public networks. Obviously, one can not charge to the teachers all accountability for the quality of education provision, but it is undeniable that a well-established initial training is essential for the classroom.

2.1 Distance Education in Higher Education

The concept of quality in distance education in Brazil is perceived in the clash of interests between the neoliberal paradigm and the relevance and social responsibility in the teacher education, considering enhancing the cultural, political and scientific in remote areas of the country.

The data presented in Census 2011 [7] and Synopsis of Higher Education [8] allow us to make inferences about the relationship between the expansion of private higher education and the perception of the concept of quality as the proposed [3, 9] through a reference model in order to observe the behavior of the cited aspects.

Distance education in Brazil adopted some pedagogical models in which quality indicators are perceived as principles that can be compromising the educational process, such as: (a) pedagogical centrality of the tutor; (b) relationship and ratio between number of students and for each teacher; (c) lack of research projects in this field. In most part of the country, the tutor has academic training at the undergraduate level and is maintained by private institutions in part-time work scheme or hourly or with a public scholarship in federal institutions.

According to [10], the expansion of enrollment in the private sector has not democratized Brazilian higher education for the courses, mostly, are really tertiary education, to name the term appearing in the publications of the World Bank. These institutions focused on teaching and students do not have access to the benefits of research, generating negative impacts on competition in the workplace and society.

In the public sphere, the democratization of higher education via distance learning was made through the implementation of the System UAB, Open University of Brazil, and has been commonly associated with the commodification of higher education policies and targeted training for individualism, as a concept of a public good. It must be said that there are many ways to implement distance learning and, given the continental size of the country, it is important to reinforce the potential of this mode of education. The distance education model adopted by UAB focused on classroom support on determined places with tutors. This model has limitations and problems, but we agreed with [4, 11, 12] that no higher education can be considered having a good quality if it is not able to contemplate relevance, social responsibility and social equity.

In general point of view, democratization of brazilian higher education admits two interpretations: (1) the model increased enrollments in private institutions who restrict the knowledge construction to a training process and (2) Public higher education offered by UAB occurred in precarious shape, with an increase of enrollments but it was not accompanied by an increase of structural and human resources.

The issue of quality has been central in educational agendas of states ranging from increased economic competitiveness to improving the quality of citizenship indicators. What is at stake is the meaning of the term quality, stress field between those who believe that the quality of education is only achieved if oriented to few and those who believe that an education has to reach more people, seeking to achieve the citizenship.

In parallel, pragmatism is necessary to realize that for many young people the expansion of enrollment has a symbolic value and considering the economic vulnerability of this people each additional year of schooling represents the achievement of a better social position. Anyway, it is clear that public policies that have expanded and continue to expand enrollments in Brazilian higher education have resulted in substantial improvements in the living conditions of young students although in general terms the structure remains polarized and stratified.

2.2 Quality in Distance Education in Mode 2 of Knowledge Production

In 1994, Gibbons, Limoges, Nowotny, Schwartzman, Scott and Trow published the book "The New Production of Knowledge" which discusses the dynamics of science and research in contemporary societies. The preface claims that there is a new knowledge of the production process in which not only the way it is produced, but it is organized, are considered elements of the process [13]. Also point to two modes of the structure of science and teaching in higher education institutions: Mode 1 refers to the organization of teaching in structures with disciplines, that is, in the words of the authors, knowledge-based disciplines [13]. Mode 2, in turn, comprises a different and varied range of research, which changes the quality control, in which the focus is on transdisciplinary and the production of knowledge is socially distributed. It involves, therefore, a constant interaction between the actors throughout the production process and that means a more socially responsible production. However, this new mode of production, according to the authors, will not replace the Mode 1. Gibbons and his co-authors also emphasize that Mode 2 is necessarily dependent of communication technologies, because the interactions and interconnections that occur on the Internet make collaborative relationships and makes the production of knowledge an increasingly activity "less self-contained" (p. 36). Quality control in this context is determined by a wide range of criteria and reflects a socially inclusive view.

In this context, [14] claim that the actual concept of autonomous and free learning feeds on humanistic theory from the theory of complexity and suggests an ontological basis for the dynamic approaches for learning and ability to handle the change.

3 Quality Assurance: A Formation Process

The whole evaluation process entails checking previously established indicators. To evaluate the quality of a distance learning course implies the definition of quality. This is the great challenge for higher education institutions when offering courses in distance learning.

Government competent bodies focus primarily in indicators related to infrastructure issues of the education institutions such as the faculty, the administrative and financial management. In addition to these issues, it is asked how the programs are being implemented, if these programs promote changes and if these changes are perceived by the participants in their professional and personal lives.

When working in course planning and production we need to consider two loci: (a) the course itself and (b) the apprentice. The evaluation of a course is always based on theoretical and philosophical assumptions underlying the understanding of teaching-learning process and the knowledge construction. As stated by [15], the evaluation can not be isolated and restricted to the limits and measures of school performance and nor be perceived as bureaucratic control instrument. One must realize the different possibilities that permeate the evaluative action as well as its uses in the context of distance education, its influence in teaching activities, the role in educational policy-making and its social commitment besides the objectives to be achieved.

The act of evaluating as emphasized by Cardinet (1990) cited [16], "is one of the essential procedures of the entire management activity" to the extent that composes the core process regulation of a system, which presupposes read reality through observation, a confrontation with the goals previously established and do the corrective action. In other words, it is a feedback mechanism that begins with the strategic planning of the course, followed by a decision-making about teaching and evaluative devices, ending with possible course corrections. Throughout the course, this feedback should be strengthened through formative assessment, understood as a process in which not only seeks to rectify mistakes but understand their occurrences and causes that enable consistent pedagogical actions.

One of the main characteristics of formative assessment is the simultaneity to the course delivery. It happens from observation and collection of data about the object that is being evaluated. Thus, we understand formative assessment as a permanent and inclusive process, which requires flexibility to carry out necessary adjustments to achieve the desired quality. Formative assessment interfere in the process, being considered as a regulatory evaluation since it allows stakeholders adjust their strategies. The essence of formative assessment is the presence of feedback.

As pointed out by [17], "evaluate a course is to diagnose the performance of each of its components - teachers, students, support staff, teaching materials, teaching project, virtual environment" in order to verify the contribution and fitness to achieve the proposed objectives.

The research group "Evaluation and cooperation in distance education", group in which we are attached with, has, over the years, established quality indicators for courses in order to promote the expected quality of the courses offered. We consider that it is essential that the institution have an evaluation methodology to achieve excellence in its processes and ongoing projects. Rethinking the indicators used in the evaluation of distance learning courses was the starting point of this research and we wanted to listen what the students consider quality in distance courses.

4 A Longitudinal Study of Quality in Distance Education Courses: Analysis of Results

The research "Quality in Distance Education: a longitudinal survey of teachers training in federal programs" was conducted based on what the students - teachers of public education participants of a postgraduate course in Technologies in Education - thought about quality in distance learning courses.

To write about the quality of formation of educators in Technologies applied to education is nowadays a complex fact. It is complex in the sense that many authors have already talked about and discussed the theme; complex because different philosophical positions have been defined and more complex yet if we consider that the question of democratization of access to technology has been extremely discussed and questioned. So, to start define the course and present the research results we should assume some principles. Some of these principles and purposes might be familiar to the reader used to digital media and technologies educational materials. However, we want to unveil them once the systematization of these principles in the development and implementation of a course are often difficult to be postulated.

- One of the challenges here is relative to the transformation of the space we live, and, specifically, the school in practice of democratic alterity;
- Technique is above all a central category to comprehend the world we live in and the position of the human being facing reality as a whole;
- In all schools where there are accounts of good practice related to the teachers, there are always evidence and experiences that can verify their commitment, enthusiasm, dedication and creativity;
- The pedagogical emphasis must rely upon didactics activities because it is here that we can find the essential to the students ate schools;
- The conception of the course must show clearly a integrating vision about the complexity in the functioning of the thought and affection of the subject that learns;
- The formation in Technologies in Education is a process in construction since it involves many dimensions linked not only to different medias but dimensions of the nature of "being in the world";
- The establishment of a dialogic relation between students and the teachers once it is from the interaction and in the interaction that it is established the learning process it can hold a reflexive nature, which creates and recreates knowledge raising critical consciousness of what should be perceived, learnt and constructed.

From these principles it was established a line of work towards the formation of teachers and the post graduate/*lato sensu* course in Technologies in Education.

The opportunity rose from a partnership with the Ministry of Education when we offered a course in Technologies in Education for teachers in practice in public high schools in the municipal and state levels in all states from Brazil. They were teachers with full degree of licentiate and effective experience in classrooms in state and municipal high schools distributed throughout Brazil. What they think about quality in distance education course?

4.1 Research Scope

The quality was seen as a set of factors in different perspectives and ranges, which aimed to meet the student of the distance mode in a range of possibilities. Quality for the development of assessment tools were defined based on indicators found in the literature and discussed the following basic factors: pedagogical mediation, usability, instructional design, virtual learning environment, teaching materials, content and pedagogical architectures and was consisted of four open questions and 25 closed. Open questions sought the following evidence:

- How Pedagogical Mediation held throughout the course contribute to their academic performance,
- How the final work orientation contributed to their writing,
- Highlight of three (3) major improvements for a next course.

- A space for a free review of the course was offered demanding about its objectives, the content, pedagogical strategies, dynamics or any other relevant topic.

Other articles regarding the same course [18–20] presented results of quantitative research that pointed to the reliability of the data collection instrument. It was possible to realize an equal distribution among the items showing a self-assessment of student. Interestingly, since almost 50 % believes it can improve its commitment to the course and about 98 % believes that the knowledge acquired throughout the course has improved their professional performance.

Regarding the students' opinions about the performance of the pedagogical mediator, we found an approval of the way in which mediators developed their work. The complexity of the pedagogical mediator performance in distance learning courses represents a bridge between the learner and the tutor and contributes to the possibility for the learner to reach its objectives [21].

When designing the mediation as a global guiding action, the role of the mediator should prioritize the development and the enhancement of skills and competencies that promote the dialogue of students with the study materials, with the teachers-authors, fostering study practices characterized by the binomial autonomy-cooperation.

Students also pointed to the importance of the mediator coupled with the students' commitment. Finally, the quantitative research showed that the teaching should work the contents to provide a link from education to social practice, understood as a starting point and arrival of the educational work. Exercises should be privileged choosing subjects taken from reality, as integrative axes for pedagogical work and the link between theory and practice.

With regard to the qualitative research, we found through the results achieved by content analysis four categorizations [20] distributed in the following classes:

- **Class 1:** Improvement of the professional student achievement composed of the responses of those who identified the participation of educational mediator as important for their professional development.
- **Class 2** and **Class 3:** Support in relation to questions and assistance in carrying out the activities and forums, respectively. Classes 2 and 3 are related to the tutor's practice, that is, its dynamic function of the discussions in the forum, learning assessment, correction and feedback of their activities, a bridge between the students and the contents of disciplines, among others.
- **Class 4:** Permanency and success on the course, highlighting the importance of educational mediator for this result and, more emphatically, as critical to the retention and graduation.

These data confirmed and reaffirmed the answers to quantitative analysis [22]. They pointed out that the pedagogical mediator and the student do not have a static situation, forming a mediator-student dyad in the context of cooperation throughout the course towards a professional qualification and change of meaning which can be produced from this cooperation.

4.2 Distance Learning Courses Reviewed: What Can We See?

The question examined in this research asked students for free comments about the course, its objectives, the content of disciplines, teaching strategies, dynamics, or any other relevant topic. We sent a digital questionnaire available to all participants and we obtained 2,124 responses, representing 68.67 % of the students enrolled at the time.

The analysis of the discursive question from respondents was performed using the software ALCESTE – Analyse Lexicale par Contexte d'un Ensemblement de Segment de Texte, which verifies the co-occurrence of words in the statements that constitute the corpus of the research in order to organize and summarize the information considered most relevant.

According to [23] the procedures for contents analysis recreate representations in two primary dimensions: syntactic and semantic. The former can identify, by means of "the way something is said or written", a likely type of audience. But the semantic dimension verifies "what is said in a text", identifying connotative and denotative meanings in a text by analyzing co-occurrences of words that, to this author, "is a statistical analysis of frequent pairs of words in a corpus of text" (p. 211).

To perform the analysis of the responses were used successive descendants classifications in the text units found by Alceste software. In order to achieve a stability in the classes founded, the context units vary in size slightly. The comparison between the classifications allows the extraction the intersection classes between the classifications made, so that the found classes represent the ideas of the dominant themes in the responses of the students. These classes consist of text units configured from the KHI2 the association between classes.

The primary forms reveal what was found in the text analyzed by the software where 75,013 different words were analyzed showing the initial connection units. These units, when segmented, form the text units or elemental context units. 98.97 % of the text available for content analysis were analyzed, resulting in five classes as shown in Fig. 1.

Naming these classes in function of the reduced forms found, we have:

- Class 1 – Pedagogical Practices
- Class 2 – Knowledge Society Vision
- Class 3 – Use of technology in the classroom
- Class 4 – Didactic and methodology
- Class 5 – Thanks to ongoing staff

Notice in the dendrogram (Fig. 1) that Classes 1 and 5 contrast with Classes 2, 3 and 4. The grouping of classes 1 and 5 denotes that both have common meanings which distinguish them from the other classes. To understand the perspective of the interviewees, and found out their perception about quality, each class was analysed individually.

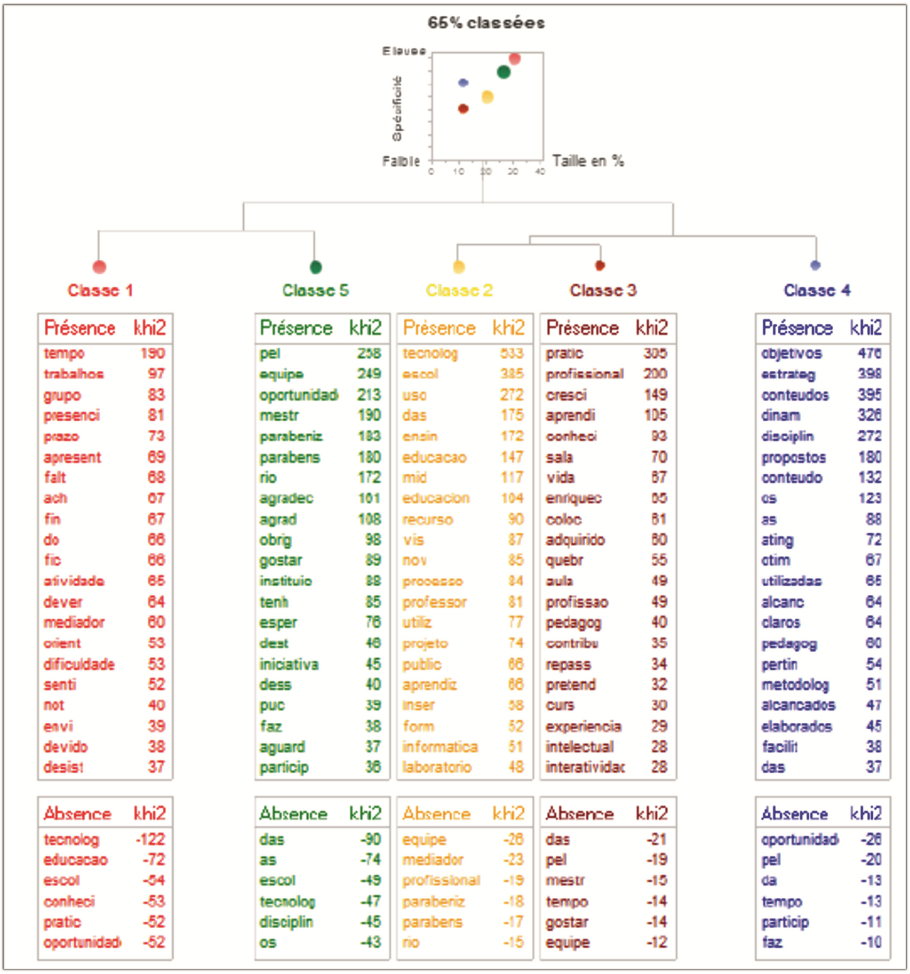

Fig. 1. Dendrogram of classes found.

4.3 Quality from the Perspective of Students

In relation to Class 1, the largest number of associated responses, some subjects have been highlighted, such as: delivery of activities, the time associated with this delivery, the stability of the learning environment and, finally, the monitoring provided by the mediator. We named the Class 1 as related to teaching practices throughout the course. As this program was about in-service formation, the dichotomy between theory and practice was minimized by the daily activities of the students themselves.

We can notice in the individual's statement #422 that the issue of a stable and informative learning environment was crucial for the achievement of activities.

> The course was very good for me but I have a very intense daily schedule and it was difficult, but I managed. I think if the environment had a space to warn about the student activities it

> will be good. I didn't find it. Sometimes I did not know what I had done and sent and I often could not see my works after sent it. (Khi2 = 21 Ind_422 Gen_F Turma_RS04).

Note the review #1361 in relation to the position of the mediator and the issue of affection.

> (…) sometimes, I was wondering how to keep the class calm without losing the affection of students (Khi2 = 17 Ind_1361 Gen_F Turma_AM04).

The same applies to the #270, which stands out as an important aspect collaboration between peers and the mediator.

> (…) I never felt alone, when I had doubts and discuss it with the mediator and the companions of the class, we created a very good link, intensely live every moment and life relationships (Khi2 = 14 Ind_270 Gen_F Turma_ES05).

The good evaluation of the course, highlighted in the statements related to Class 1, is reinforced in Class 5, which refers to thank for the opportunity to be part of the course.

Class 2, which we named "The knowledge society vision", is related to the change that occurs in teacher education towards a society permeated by technology. This change lies in the use of technology in the classroom and in activities that students take in their professional life, that is, in Educational Technology Centers of states or municipalities, as the students were teachers of public schools.

> The course was essential to my academic training and performance in technologies applied in education. It gave me a vision of my role as multiplier in the training of teachers regarding the pedagogical use of various media in our schools and in the improvement in the teaching-learning process (Khi2 = 32 Ind_618 Gen_M Turma_AC04).

> (…) Before the transformation that is happening in our society, we can consider that we are live discussion times that allow us to reflect on the information and communication technologies in the context of distance education (Khi2 = 31 Ind_1073 Gen_M Turma_SP07).

> The technologies ongoing education provided me with a unique learning regarding the use of ICT in schools. Moreover, it enabled me to review ideas and educational strategies, accompanied by a new educational view (Khi2 = 29 Ind_1437 Gen_F Turma_AL01).

> (…) The way of working with projects. Even I have suggested to the next show our school boards the title: Professor in the digital age. Based on this theme we will develop our action plan (Khi2 = 24 Ind_549 Gen_F Turma_MG03).

The answers of the Class 2 show a concern beyond the course, pointing to his application, professional development, engagement in obtaining the skills necessary to meet the demand of public policies.

Class 3, which appears grouped with the Class 2, refers to the use of technology in the classroom and the improvement of didactic situations in the classroom with the use of technology. The students' statements in this class pointed to the teachers training and the possibility of modifying their teaching in the classroom.

The #350 explains the change in its attitude in the classroom, while the #1350 highlights the possibility of change in the methods used, showing the questioning methodology is good for the class.

> (…) Everyone should go through this experience to grow professionally and modify their attitudes and methodologies (Khi2 = 21 Ind_350 Gen_F Turma_DF02).

> It is a very rich current knowledge and as unique opportunity in the professional life of teachers, contributing to a rethink in pedagogical practice (Khi2 = 16 Ind_1350 Gen_F Turma_CE05).

> (…) I consider very productive this course, with its structure that greatly contributed to my teaching practice, because I learned and experienced situations that I already dominate and it makes me think about it (Khi2 = 26 Ind_399 Gen_F Turma_PR03).

> (…) Really liked the course, I think it helped me in my professional and personal trajectory. I learned a lot and I want to pass this knowledge to my students and does not keep them to myself (Khi2 = 17 Ind_1887 Gen_F Turma_SC05).

In Class 4, related Classes 2 and 3, students pointed to the content and its presentation, using various situations and educational structures and emphasizing the importance of these elements in your professional life. We name this class as a "Teaching and Methodology".

> (…) The contents of the courses were great and easy to understand. The strategies and the dynamics contributed greatly to my education (Khi2 = 59 Ind_1971 Gen_F Turma_AP04).

> (…) The content addressed were always very good. Dynamic and used teaching strategies were extremely important for the development of the course and for their understanding (Khi2 = 42 Ind_543 Gen_F Turma_DF02).

> (…) The content and goals of each discipline are clear, easy to understand. The dynamics used in activities are very interesting (Khi2 = 41 Ind_1967 Gen_F Turma_MA01).

Important to note that the five classes found by analysis, (1) Teaching practices, (2) The Knowledge Society Vision, (3) The use of technology in the classroom, (4) Teaching and Methodology (5) Thanks to the staff course, show a concern for students beyond the course held.

5 Final Comments

From the principles already presented in the beginning of this paper, we can establish the basis of the course from the mediation between the subject, the student – subject of our work – and other actors in the process such as the teacher-tutor, the supervisors and the actual content of the course. In this sense, we understand that technology is the object that enables communication among all and the locus of support to the teaching practice. Technology and the virtual learning environment support store and enable actors from the course to reflect, dialogize, states to decode interactions. We search to create a didactic-pedagogical material that could enable dialogue. We found in [24] the reference for didactic situations. These can be defined as a set of relations explicitly or implicitly established between one student and group of students, a determined environment (that include eventually instruments or objects) and an educative system with the purpose of making students suited for knowledge. The main characteristics of didactic situations could be described as:

- The students hold themselves responsible for the organization of their activity to try to solve the proposed problem;
- The activity of the students is oriented to obtain results previously explained and that can be identified by the students;
- The solution of the problem involves a decision making process in the students part to attain the pursued goal;
- The students can resort to different strategies to solve the formulated problem;
- The students engage in many social relations: communications, debates or negotiations with each other and the teacher.

Therefore, what defines a didactic situation is intentional character, meaning the fact of being constructed with an explicit purpose to guarantee apprenticeship to students. A didactic situation is composed of activities that can be defined as means used by the teachers to work concepts that will allow the students to experience needed practices for their own formation and development. We name these activities pedagogical strategies, which are pedagogical actions developed by the students with the purpose of building an apprenticeship about a determined content. The best activity to be used will depend upon factors such as: who are the students, what is the context they are inserted to, technological conditions, for instance. According to our experience, the different activities have positive contributions and limitations that can be used in isolation or in combination or group. What we cannot lose track of are the educational values we believe in.

The course locus of this research aimed to afford specialization and to update and deepen central questions and themes that proceed from the principles of integration of media and the reconstruction of the pedagogical practice. The organization of the course attempted to define different pedagogical structures towards the conceptual command of its work. For the same reason, many forms of presentation – theoretical and empirical – were established having as its objective the acquisition of essential abilities for the search and selection of information, and construction of knowledge.

The important thing present in this paper was to verify as of the content analysis how classes are formed from the responses of the students, so that we could understand what emerged as ongoing quality concept for students in distance learning courses. We emphasized the question about the course, its objectives, the discipline content, pedagogical strategies, dynamics, or any other topic that the student consider as relevant. We look for upward rating because this shows a complementary results and aid in the representation of local relations between the forms of the same class. We can observe this classification the Khi2 of each word within the class helping us to name it since the nomination of the class comes the concept of quality in the view of the students. So what can be considered as quality of a distance learning course on students' view? If we return to the beginning of this article where one takes the quality as a set of factors in different perspectives and ranges from the paradigm of relevance and social responsibility, there are some factors in the free issue analysis, namely: teaching strategies, objectives, syllabus and its dynamics. However, as we pointed before, the pedagogical strategies need activities that can be defined as vehicles used by teachers to work the concepts. This will allow the student to live the experiences necessary for self-transformation. One of the pedagogical mediator role is use pedagogical strategies in order to help the group find their rhythm of interaction and work, his style and personality in the learning community.

Important to realize that the five classes indicate the course applicability, the professional development, the engagement in obtaining the necessary skills to meet the demand of public policies. Therefore, the quality of a course can only be determined in a given context and analyzed from the perspective of different actors involved in the process. Our final point in this paper was to show the concept of quality linked to the context where the course occurs.

References

1. Castells, M., Cardoso, G. (org.).: A sociedade em rede do conhecimento à acção política. Conferência promovida pelo Presidente da República. Centro Cultural de Belém. 4 e 5 de Março de (2005). http://biblio.ual.pt/Downloads/REDE.pdf
2. Bertolin, J.C.G.: Qualidade em educação superior: da diversidade de concepções a inexorável subjetividade conceitual. Avaliação **14**(1), 127–149 (2009). Campinas; Sorocaba, SP
3. Bertolin, J.C.G.: Avaliação da educação superior brasileira: relevância, diversidade, equidade e eficácia do sistema em tempos de mercantilização. Avaliação **14**(2), 351–383 (2009). Campinas; Sorocaba, SP
4. Dias Sobrinho, J., Brito, M.R.F.: La educación superior en Brasil: principales tendencias y desafios. Avaliação **13**(2), 487–507 (2008). Sorocaba
5. Castells, M.: A sociedadeemRede: do conhecimento à Política. In: Castells, M., Cardoso, G. (org.) A sociedade em Rede do Conhecimento à Acção Política. Conferência promovida pelo Presidente da República. Centro Cultural de Belém. 4 e 5 de Março de, pp. 17–30 (2005). http://biblio.ual.pt/Downloads/REDE.pdf
6. Mota, R., Chaves Filho, H., Cassiano, W.S.: A universidade aberta do Brasil: democratização do acesso à educação superior pela rede pública de educação a distância. In: Chaves Filho, H. (org.) Desafios da educação a distância na formação de professores. Brasília: MEC – Secretaria de Educação a Distância, pp. 13–26 (2006)
7. Brasil. Ministério da Educação. Sinopse da educação superior 2012 - graduação. - Brasília: Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (2013). http://portal.inep.gov.br/superior-censosuperior-sinopse. Acessadoem 20 March 2014
8. Brasil. Ministério da Educação. Censo da educação superior 2012: resumo técnico. - Brasília: Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (2014). http://download.inep.gov.br/download/superior/censo/2012/resumo_tecnico_censo_educacao_superior_2012.pdf
9. Bertolin, J.C.G.:Avaliação da qualidade do sistema de educação superior brasileiro em tempos de mercantilização – período 1994–2003. Tese (Doutorado em Educação) – Universidade Federal do Rio Grande do Sul, Porto Alegre (2007)
10. Leher, R., Educação no governo de Lula da Silva: a ruptura que não aconteceu. In: Osanos Lula: contribuições para um balanço crítico 2003–2010, pp. 369–412. Garamound, Rio de Janeiro (2010)
11. Sobrinho, J.D.: Democratização, qualidade e crise da educação superior: faces da exclusão e limites da inclusão. Educação and Sociedade **31**(113), 1223–1245 (2010)
12. Sobrinho, J.D.: Políticas y conceptos de calidad: dilemas y retos. Avaliação **17**(3), 601–618 (2012). Campinas; Sorocaba, SP

13. Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M.: The New Production of Knowledge: Dynamics of Science and Research in Contemporary Societies. Sage Publications, Thousand Oaks (1994)
14. Hase, S., Kenyon, C.: Andragogy to Heutagogy (2000). http://ultibase.rmit.edu.au/Articles/dec00/hase1.pdf. Acesso em 27 November 2014
15. Azevedo, A.B., Sathler, L.: Avaliaçãoinstitucional – relevância e usos na EAD. 14º Congresso Internacional ABED de Educação a Distância, Santos (SP) (2008). http://www.abed.org.br/congresso2008/tc/552008124132PM.pdf. Acesso em 27 November 2014
16. Bonniol, J.J., Vial, M.: Modelos de Avaliação: textos fundamentais, p. 107. Artmed, Porto Alegre (2001)
17. Carlini, A.L., Ramos, M.P.: A avaliação do curso. In: Litto, F.M., Formiga, M. (eds.) Educação a distância: o estado da arte, pp. 161–165. Pearson Education, São Paulo (2009). Dias sobrinho, J.: Calidad, pertinencia y responsabilidade social de la universidad latino americana y caribeña. In: IESALC/UNESCO. Tendencias de la educación superior enAmérica Latina y el Caribe, pp. 87−112, Caracas (2008). http://www.iesalc.unesco.org.ve/index.php?option=com_content&view=article&id=2%3Atendencias&catid=3%3Acontenido&Itemid=14&lang=es.
18. Campos, G.H.B., Roque, G.O., Amaral, S.B.: As Relações Colaborativas: Desafios da Docência na Educação a Distância, vol. 1, 1st edn, p. 128. CRV Editora, Curitiba (2011)
19. Campos, G.H.B., Ziviani, C., Silva, E.C.E., Roque, G.O.: Díade mediador-aluno: Relações de cooperação. Tecnologias, Sociedade e Conhecimento **1**, 57–79 (2013)
20. Roque, G.O., Pedrosa, S., Campos, G.H.B.: Reflexões sobre a teoria e prática da mediação. In: 18° Congresso Internacioal ABED de Educação a distância. São Luiz, Maranhão (2012)
21. Moran, J.M., Masetto, M., Behrens, M.: Novas Tecnologias e Mediação Pedagógica, 15th edn. Papirus, São Paulo (2008)
22. Campos, G.H.B., Ziviani, C., Roque, G.O.B.: Análise da avaliação da qualidade em educação a distância no modo 2 da produção do conhecimento. Revista e-Curriculum **11**(1), 181–200 (2013). São Paulo
23. Bauer, M.W.: Análise de Conteúdo Clássica: uma revisão. In: Bauer, M.W., Gaskell, G. (eds.) Pesquisa qualitativa com texto, imagem e som: um manual prático, 6th edn, pp. 189–217. Petrópolis, Vozes (2007)
24. Brousseau, G.: Glossaire de quelques Concepts de la Théorie des Situations Didactiques en Mathématiques (2003). http://perso.orange.fr/daest/guy-b

Verifying the Stability and Sensitivity of Learning Analytics Based Prediction Models: An Extended Case Study

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Abstract. In this empirical contribution, a follow-up study of previous research [1], we focus on the issues of stability and sensitivity of Learning Analytics based prediction models. Do predictions models stay intact, when the instructional context is repeated in a new cohort of students, and do predictions models indeed change, when relevant aspects of the instructional context are adapted? Applying Buckingham Shum and Deakin Crick's theoretical framework of dispositional learning analytics combined with formative assessments and learning management systems, we compare two cohorts of a large module introducing mathematics and statistics. Both modules were based on principles of blended learning, combining face-to-face Problem-Based Learning sessions with e-tutorials, and have similar instructional design, except for an intervention into the design of quizzes administered in the module. We analyse bivariate and multivariate relationships of module performance and track and disposition data to provide evidence of both stability and sensitivity of prediction models.

Keywords: Blended learning · Dispositional learning analytics · E-Tutorials · Formative assessment · Learning dispositions

1 Introduction

Learning analytics (LA) provide institutions with opportunities to support student progression and to enable personalised, rich learning [2–4]. According to Bienkowski et al. [2, p. 5], "education is getting very close to a time when personalisation will become commonplace in learning", although several researchers [5, 6] indicate that most institutions may not be ready to exploit the variety of available datasets for learning and teaching. Many learning analytics applications use data generated from learner activities, such as the number of clicks [7, 8], learner participation in discussion forums [9, 10], or (continuous) computer-assisted formative assessments [8, 11, 12].

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User behaviour data are frequently supplemented with background data retrieved from learning management systems (LMS) [10] and other student admission systems, such as accounts of prior education [13–15].

In [16], six objectives are distinguished in using learning analytics: predicting learner performance and modelling learners, suggesting relevant learning resources, increasing reflection and awareness, enhancing social learning environments, detecting undesirable learner behaviours, and detecting affects of learners. Although the combination of self-report learner data with learning data extracted from e-tutorial systems (see below) allows us to contribute to at least five of these objectives of applying learning analytics, we will focus in this contribution on the first objective: predictive modelling of performance and learning behaviour [17, 18]. The ultimate goal of this predictive modelling endeavour is to find out which components from a rich set of data sources best serve the role of generating timely, informative feedback and signalling risk of underperformance. In designing such prediction models, there is always a balance between prediction accuracy at the one side, and the generalizability of the prediction model at the other side [18]. Models that are strongly context specific will typically achieve high prediction accuracy, but perform only within contexts very similar to the one they are designed for, and not outside such contexts. Relative invariance of prediction models over several modules making up an academic program is thus an important aim in the design of prediction models. At the same time, prediction models need to be sufficiently context specific, for instance in order to be able to analyse the effect of interventions into the instructional system. In this study, we focus on both of these issues within the empirical context of a large module on introductory quantitative methods. Our study is a follow-up study of previous research [1, 19], in which the role of formative assessment based LA is analysed within one cohort of students. In the current study, we extend our sample with a second cohort, with the aim to investigate both the stability of the prediction models over different cohorts, as well as the sensitivity of those prediction models for relevant changes in the instructional design.

2 Application Context

2.1 Dispositional Learning Analytics

Buckingham Shum and Deakin Crick [20] propose a dispositional learning analytics infrastructure that combines learning activity generated data with learning dispositions, values and attitudes measured through self-report surveys, which are fed back to students and teachers through visual analytics. For example, longitudinal studies in motivation research [21, 22] and students' learning approaches indicate strong variability in how students learn over time in face-to-face settings (e.g., becoming more focussed on deep learning rather than surface learning), depending on the learning design, teacher support, tasks, and learning dispositions of students. Indeed, in a study amongst 730 students [15] found that positive learning emotions contributed positively to becoming an intensive online learner, while negative learning emotions, like boredom, contributed negatively to learning behaviour. Similarly, in an online community of practice of 133 instructors supporting EdD students, [23] found that self-efficacy (and expertise) of instructors predicted online contributions. In addition, a very recent overview study into the role learner emotions in applications of LA, [24] distinguished no less than hundred different facets of learner emotions determining students' learning behaviours.

However, studies combining LMS data with intentionally collected data, such as self-report data stemming from student responses to surveys, are the exception rather than the rule in learning analytics [1, 5, 10, 11, 25]. In our first empirical contribution focusing on a large scale module in introductory mathematics and statistics, we aimed to provide a practical application of such an infrastructure based on combining longitudinal learning and learner data. In collecting learner data, we opted to use three validated self-report surveys firmly rooted in current educational research, including learning styles [26], learning motivation and engagement [27], and learning emotions [28]. This operationalisation of learning dispositions closely resembles the specification of cognitive, metacognitive and motivational learning factors relevant for the internal loop of informative tutoring feedback (e.g., [29, 30]. For learning data, data sources were used from more common learning analytics applications, and constitute both data extracted from an institutional LMS [10] and system track data extracted from the e-tutorials used for practicing and formative assessments (e.g., [1, 8, 19]). The prime aim of the analysis was predictive modelling [17], with a focus on the roles (each of) the 100+ predictor variables from the several data sources can play in generating timely, informative feedback to students. Main findings from our previous study indicate that data derived from formative assessments play a very dominant role in predicting students success, but are generally not available in the first weeks of a module. When in need for timely feedback, the combination of disposition data, diagnostic entry test data, and early track data from e-tutorial systems used for practicing, constitute a second best data source in predicting student success. However, results were obtained from a single cohort of students who were all exposed to the same learning design. This leaves us with the question whether the learning analytics approach we chose is stable across multiple cohorts and sensitive enough to detect changes in the learning design.

2.2 Extended Case Study: Blended Learning of Mathematics and Statistics Using E-Tutorials and Formative Assessment

Comparable to our initial study, subjects in the current study are freshmen students in a quantitative methods (mathematics and statistics) module taught at the business and economics school at Maastricht University. This module is directed at a large and diverse group of students, which benefits the research design. The current study extends the cohort investigated in the initial study with the cohort of students who took part in the module in the consecutive year. For both cohorts, Blackboard serves as a basic LMS system to share module information to students. Given the restricted functionality of this LMS in terms of personalised, adaptive learning content with rich varieties of feedback and support provision, two external e-tutorials were utilised: MyStatLab (MSL) and MyMathLab (MML). These e-tutorials are generic LMSs for learning statistics and mathematics developed by the publisher Pearson. Please see [1, 19] for a more detailed description of these tools.

The MyLab functionalities used in the module are that of practicing (replacing traditional practicals), formative assessment, and quizzing. Quizzing allows students to achieve a bonus on the score of the final written exam, determining the pass/fail decision for the module. Although quizzing makes use of the same materials as the self-steered formative assessments, and the weight of quiz performance in the pass/fail decision is limited, the quiz element does entail some summative aspects beyond important formative ones. And it has been in the quizzing that we revised the instructional design of the module. In the first cohort, quiz items were randomly selected from the same pool of items students could access in their formative assessments. Thus by putting sufficient effort in self-assessment, students could achieve knowledge about all item types in the quiz (not with the exact items themselves, since items are parametrized). To avoid stimulating students to repeat formative assessments over and over again only to learn all different item types, we split all item pools into two non-overlapping sub pools, one for self-assessments, the other for quizzing. Thereby, the added second cohort in the current study was subjected to a somewhat different learning design. It is exactly this change that prediction models might pick up from the LA studies if they appear to be sufficiently sensitive to the instructional design.

3 Research Methods

3.1 Research Questions

Combining empirical evidence on how students' usage and behaviour in LMS influences academic performance (e.g. [8, 10, 13, 31]), how the use of e-tutorials or other formats of blended learning affects performance (e.g., [32]), and how feedback based on learning dispositions stimulates learning [20], our study aims to discover the relative contributions of LMSs, formative testing, e-tutorials, and applying dispositional learning analytics to student performance. Like in our initial study, the prime aim of the analysis is predictive modelling [8, 17], with a focus on the role each of these data sources can play in generating timely, informative feedback for students. However, this aim is extended with a focus on the stability of prediction models, defined as the similarity of the prediction models in the two subsequent cohorts, and the sensitivity of the prediction models: will they signal the revision in instructional design. This leads to the following research questions:

Q1 To what extent do distinct data sources, such as (self-reported) learning dispositions of students, LMSs and e-tutorial data (formative assessments) predict academic performance over time?

Q2 To what extent are the prediction models stable, in the sense that predictive modelling in both cohorts results in invariant model structures with similar weights of the prediction variables?

Q3 To what extent are prediction models sensitive, in the sense that predictive modelling is indicative of the revision of the instructional design the additional cohort was subjected to?

3.2 Methodology

Context of the Study. The educational system in which students learn mathematics and statistics is best described as a 'blended' or 'hybrid' system. The main component is face-to-face: problem-based learning (PBL), in small groups (14 students), coached by a content expert tutor [33–35]. Participation in these tutorial groups is required, as for all modules based on the Maastricht PBL system. The use of the two e-tutorials that form the online component of the blend (see Tempelaar et al., 2013) is optional. This optional component fits the Maastricht educational model, which is student-centred and places the responsibility for making educational choices primarily on the student [11, 34]. At the same time, due to strong diversity in prior knowledge in mathematics and statistics, not all students, in particular those at the high performance end, will benefit equally from using these environments. However, the use of e-tutorials and achieving good scores in the practicing modes of the MyLab environments is stimulated by making bonus points available for good performance in the quizzes.

In total, the duration of the module is seven weeks. The student-centred characteristic of the instructional model first and foremost requires adequate informative feedback to students so that they are able to monitor their study progress and their topic mastery in absolute and relative sense. The provision of relevant feedback starts on the first day of the module when students take two diagnostic entry tests for mathematics and statistics [11]. Feedback from these entry tests provides a first signal of the importance for using the MyLab platforms. Next, the MML and MSL-environments take over the monitoring function: at any time students can see their progress in preparing the next quiz, get feedback on the performance in completed quizzes, and on their performance in the practice sessions. The same (individual and aggregated) information is also available for the tutors in the form of visual dashboards [16, 36]. Although the primary responsibility for directing the learning process is with the student, the tutor acts complementary to that self-steering, especially in situations where the tutor considers that a more intense use of e-tutorials is desirable, given the position of the student concerned. In this way, the application of learning analytics shapes the instructional support.

Participants. From the two most recent cohorts of freshmen (2013/2014 and 2014/2015) all students who in some way participated in learning activities (i.e., have been active in BlackBoard) were included: 1005 and 1006 students respectively. A large diversity in the student population is present: only 25 % were educated in the Dutch high school system. The largest group, 45 % of the freshmen, were educated according to the German Abitur system. High school systems in Europe differ strongly, most particularly in the teaching of mathematics and statistics. Therefore, it is crucial that the first module offered to these students is flexible and allows for individual learning paths [11, 12]. In the investigated module, students worked an average 32.6 h in MML and 20.7 h in MSL, 30 % to 40 % of the available time of 80 h for learning in both topics.

3.3 Instruments and Procedure

We will investigate the relationships between a range of data sources, leading to in total 102 different variables. In the subsections that follow, the several data sources that provide the predictor variables for our predictive modelling will be described.

Registration Systems Capturing Demographic Data. In line with academic retention or academic analytics literature [14, 31], several demographic factors are known to influence performance, and are therefore logical factors to include in learning analytics models. A main advantage of this type of data is that institutions can relatively easily extract this information from the student admissions office.

Demographic data were extracted from the applicable administrative systems: nationality, gender, age and prior education. Since, by law, introductory modules like ours need to be based on the coverage of Dutch high school programs, we converted nationality data into an indicator for having been educated in the Dutch high school system. The two cohorts showed no significant difference on any of the demographic variables. 24 % of students are educated in the Dutch higher education system, 76 % of students in international systems, mostly of continental European countries. About 39 % of students are female, with 61 % males. Age demonstrates very little variation (nearly all students are below 20), and no relationship with any performance, and is excluded. The main demographic variable is the type of mathematics track in high school: advanced, preparing for sciences or technical studies in higher education, or intermediate, and preparing for social sciences (the third level, mathematics for arts and humanities, does not provide access to our program). Exactly two third of the students has an intermediate mathematics level, one third has an advanced level ([11, 12, 35] for a detailed description.).

Diagnostic Entry Tests. At the very start of the module, so shaping part of Week 0 data, are diagnostic entry tests for mathematics and statistics all students were required to do. Both entry tests are based on national projects directed at signalling deficiencies in the area of mathematics and statistics encountered in the transition from high school to university (see [15] for an elaboration). Topics included in the entry tests refer to foundational topics, often covered in junior high school programs, such as basic algebraic skills or statistical literacy.

Learning Dispositions Data. Learning dispositions of three different types were included: learning styles, learning motivation and engagement, and learning emotions. The first two facets were measured at the start of the module, and from the longitudinal perspective are assigned to Week 0 data. Learning style data are based on the learning style model of Vermunt [26]. Vermunt's model distinguishes learning strategies (deep, step-wise, and concrete ways of processing learning topics), and regulation strategies (self, external, and lack of regulation of learning). Recent Anglo-Saxon literature on academic achievement and dropout assigns an increasingly dominant role to the theoretical model of Martin [27]: the 'Motivation and Engagement Wheel'. This model includes both behaviours and thoughts, or cognitions that play a role in learning. Both are subdivided into adaptive and mal-adaptive (or obstructive) forms. Adaptive thoughts consist of Self-belief, Value of school and Learning focus, whereas adaptive behaviours consist of Planning, Study management and Perseverance. Maladaptive thoughts include Anxiety, Failure Avoidance, and Uncertain Control, and lastly, maladaptive behaviours include Self-Handicapping and Disengagement. As a result, the four quadrants are: adaptive behaviour and adaptive thoughts (the 'boosters'), mal-adaptive behaviour (the 'guzzlers') and obstructive thoughts (the 'mufflers').

The third component, learning emotions, is more than a disposition: it is also an outcome of the learning process. Therefore, the timing of the measurement of learning emotions is Week 4, halfway into the module, so that students have sufficient involvement and experience in the module to form specific learning emotions, but still timely enough to make it a potential source of feedback. Learning emotions were measured through four scales of the Achievement Emotions Questionnaire (AEQ) developed by Pekrun et al. [28]: Enjoyment, Anxiety, Boredom and Hopelessness. All learning dispositions are administered through self-report surveys scored on a 7-point Likert scale.

Learning Management System. User track data of LMS are often at the heart of learning analytics applications. Also in our context intensive use of our LMS, BlackBoard (BB), has been made. In line with [9], we captured tracking data from six learning activities. First, the diagnostic entry tests were administered in BB, and through the MyGrades function, students could access feedback on their test attempts. Second, surveys for learning dispositions were administered in BB. Third, two lectures per week were provided, overview lectures at the start of the week, and recap lectures at the end of the week, which were all videotaped and made available as webcasts through BB. Fourth, several exercises for doing applied statistical analyses, including a student project, were distributed through BB, with a requirement to upload solutions files again in BB. Finally, communication from the module staff, various module materials and a series of old exams (to practice the final exam) were made available in BB. For all individual BB items, Statistics Tracking was activated to create use intensity data on BB function and item level.

E-Tutorials MyMathLab and MyStatLab. Students worked in the MyMathLab and MyStatLab e-tutorials for all seven weeks, practicing homework exercises selected by the module coordinator. The MyLab systems track two scores achieved in each task, mastery score (MyLabMastery) and time on task (MyLabHours). Those data were aggregated over the on average 25 weekly tasks for mathematics, and about 20 tasks for statistics, to produce four predictors, two for each topic, for each of the seven weeks.

The three (bonus) quizzes took place in the weeks 3, 5 and 7. Quizzes were administrated in the MyLab tools, and consisted of selections of practice tasks from the two previous weeks. As indicated: the single revision in the instructional design of the module between the two class years is in the inclusion of quiz items in the item pool availability for self-assessment.

Academic Performance. Four measures of academic performance in the Quantitative Methods module in both cohorts were included for predictive modelling: score in both topic components of the final, written exam, MExam and SExam, and aggregated scores for the three quizzes in both topics, MQuiz and SQuiz, where M refers to the topic mathematics, and S refers to the topic Statistics.

3.4 Data Analysis

Complete data on all variables was obtained for 874 respectively 879 students (87 %). Prediction models applied in this study are all of linear, regression type. More complex models have been investigated, in particular interaction models. However, none of these more advanced model types passed the model selection criterion that prediction models should be stable over all seven weekly intervals. Collinearity existing in track data in a similar way forced us to aggregate that type of data into weekly units; models based on less aggregated data such as individual task data gave rise to collinearity issues.

4 Results

The aim of this study being predictive modelling in a rich data context, we will focus the reporting on the coefficient of multiple correlation, R, of the several prediction models. Although the ultimate aim of prediction modelling is often the comparison of explained variation, which is based on the square of the multiple correlation, we opted for using R itself, to allow for more detailed comparisons between alternative models. Values for R are documented in Table 1 for prediction models based on alternative data sets, and for both cohorts. For data sets that are longitudinal in nature and allow for

Table 1. Predictive power, as multiple correlation R, of various data sets and various timings, for four performance measures, two cohorts.

Data source	Timing	MExam 2013	SExam 2013	MQuiz 2013	SQuiz 2013	MExam 2014	SExam 2014	MQuiz 2014	SQuiz 2014
Demographics	Week 0	.43	.29	.39	.21	.24	.22	.27	.21
EntryTests	Week 0	.43	.30	.45	.24	.37	.28	.47	.29
Learning styles	Week 0	.24	.22	.22	.23	.20	.23	.18	.25
Motivation and engagement	Week 0	.30	.31	.33	.32	.19	.24	.23	.23
BlackBoard	Week 0	.12	.09	.16	.15	.19	.07	.16	.10
AllWeek 0	Week 0	.59	.46	.58	.43	.48	.43	.55	.43
BlackBoard	Week 1	.13	.13	.19	.16	.20	.08	.17	.11
MyLabs	Week 1	.37	.30	.48	.47	.34	.28	.44	.36
AllWeek 1	Week 1	.61	.50	.66	.57	.52	.49	.63	.53
BlackBoard	Week 2	.15	.14	.20	.17	.21	.10	.18	.11
MyLabs	Week 2	.39	.36	.50	.50	.36	.34	.45	.39
AllWeek 2	Week 2	.62	.52	.67	.64	.53	.52	.64	.58
BlackBoard	Week 3	.16	.14	.20	.17	.22	.11	.20	.11

(*Continued*)

Table 1. (*Continued*)

Data source	Timing	MExam 2013	SExam 2013	MQuiz 2013	SQuiz 2013	MExam 2014	SExam 2014	MQuiz 2014	SQuiz 2014
MyLabs	Week 3	.47	.41	.61	.56	.41	.35	.47	.39
Quiz1	Week 3	.67	.58	.86	.76	.60	.54	.81	.74
AllWeek 3	Week 3	.74	.66	.89	.81	.66	.64	.85	.79
Learning Emotions	Week 4	.48	.33	.49	.30	.32	.25	.38	.25
BlackBoard	Week 4	.16	.14	.22	.19	.24	.12	.21	.15
MyLabs	Week 4	.50	.45	.65	.60	.45	.40	.51	.40
AllWeek 4	Week 4	.79	.67	.90	.82	.76	.66	.86	.80
BlackBoard	Week 5	.17	.14	.22	.19	.24	.12	.21	.15
MyLabs	Week 5	.52	.50	.68	.66	.46	.44	.53	.46
Quiz2	Week 5	.72	.61	.96	.93	.67	.64	.94	.93
AllWeek 5	Week 5	.77	.68	.97	.94	.72	.71	.95	.94
BlackBoard	Week 6	.17	.15	.22	.21	.25	.13	.22	.15
MyLabs	Week 6	.52	.51	.69	.66	.46	.45	.52	.46
AllWeek 6	Week 6	.78	.69	.97	.94	.73	.71	.96	.94
BlackBoard	Week 7	.18	.15	.22	.21	.26	.14	.23	.15
MyLabs	Week 7	.53	.51	.69	.67	.48	.46	.55	.47
Quiz3	Week 7	.72	.61	1.00	1.00	.69	.66	1.00	1.00
AllWeek 7	Week 7	.78	.69	1.00	1.00	.75	.72	1.00	1.00

Note: MExam and SExam refer to exam scores in topics mathematics and statistics; MQuiz and SQuiz to the corresponding quiz score.

incremental weekly data sets, the growth in predictive power is illustrated in time graphs for BB track data, MyLabs track data, formative test performance data and all data combined. To better facilitate comparison, all graphs share the same vertical scale.

4.1 Predictive Power Per Topic

In the comparison of the several columns of prediction accuracy in Table 1, one of the most striking outcomes is that the predictive power for mathematics uniformly dominates that for statistics, in both cohorts, and for both performance measures exam and quiz (with one single exception). The difference is easy to explain: students enter university with very different levels of prior knowledge of and prior education in mathematics. For that reason, demographics (containing the dummy for high school math at advanced level) as well as entry test data contribute strongly in predictive power. Statistics, not being part of the curriculum of most European high school systems, does not profit from the same type of predictors. This outcome corroborates findings from previous research [11, 14, 31], that prior education seems to be a useful factor to include in learning analytics modelling. The single predictor performing equally well in both topics represents learning dispositions: both learning styles, and motivation and engagement variables, do not differentiate between topics, signalling the unique contribution that learning dispositions can possess in LA based prediction models.

4.2 Predictive Power Per Performance Measure

In the comparison of predictive power of the two performance measures, exam and quiz, of corresponding topics and cohorts, we find less articulated differences. Most predictor variables predict exam performance with similar accuracy as quiz performance. The clear exception to this outcome relates the system tracking data collected from the two MyLab systems: time in MML and MSL, and mastery in MML and MSL.

Given the strong ties between the self-steered formative assessment in the e-tutorials, and the quizzing administered in the same e-tutorials, we find that MyLab track data have much stronger predictive power toward quiz performance, than toward exam performance (the same is true for quiz performance acting as predictor for later quizzes).

4.3 Predictive Power Per Data Source

In a comparison of prediction accuracy of the several data sources, the outcomes of this study are fully in line with our findings in previous research [1, 19]. Most powerful predictor is found in the cognitive data: scores on entry tests, and scores in quizzes. From the moment the first quiz data become available, other data sources hardly contribute anymore in the prediction of performance measures, as is evident from a comparison of Figs. 3 and 4. However: the first quiz data are only available at the end of the third week, about half-way the module. More timely data, already available from the start of the module on, is found in the track data of the MyLab systems (Fig. 2).

These data dominate the predictive power of track data collected from the LMS (Fig. 1).

As Fig. 1 exhibits, the predictive power of track data generated from the BlackBoard LMS is rather limited, not going beyond a value of 0.25 for the multiple R for any of the performance measures. Remarkably, the single week that contributes most to predictive power, is the week before the start of the module (week 0), distinguishing students who prepare in advance, from those who do not.

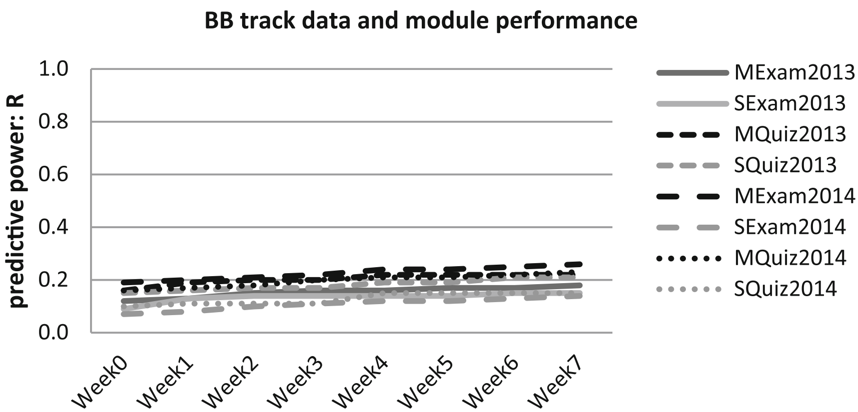

Fig. 1. Predictive power of BB track data for six performance measures.

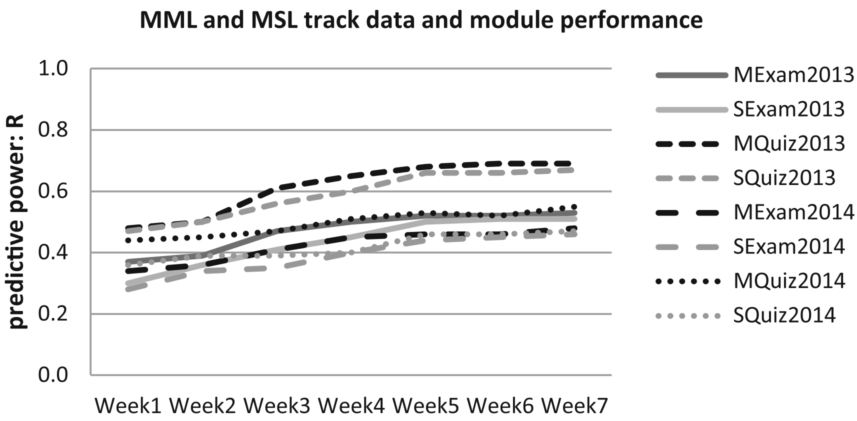

Fig. 2. Predictive power of MML and MSL track data in practice mode for six performance measures.

In contrast, track data from both e-tutorial systems have a much stronger 'track record' in predicting module performance, with multiple R values ranging between 0.3 and 0.5 already for week 1 data, accumulating to values between 0.45 and 0.70 for track data of all weeks, as visible from Fig. 2.

Strongest predictive power of an individual data set is to be found in the data of the quizzes, or formative tests. In Fig. 3, these data are combined with the data of the diagnostic entry tests, dated week 0. Although the information within the entry test compares well with e.g. the e-tutorial track data, the quiz data available from week 3 onwards exemplify a clear jump in predictive power.

The last exhibit, Fig. 4, combines all data: BB track data, e-tutorial track data, entry test and quiz data, and the disposition data (not exhibited before). It deviates hardly from the previous figure in the second part of the module, due to the dominant role of formative test data. Early predictions do however improve by including other types of data.

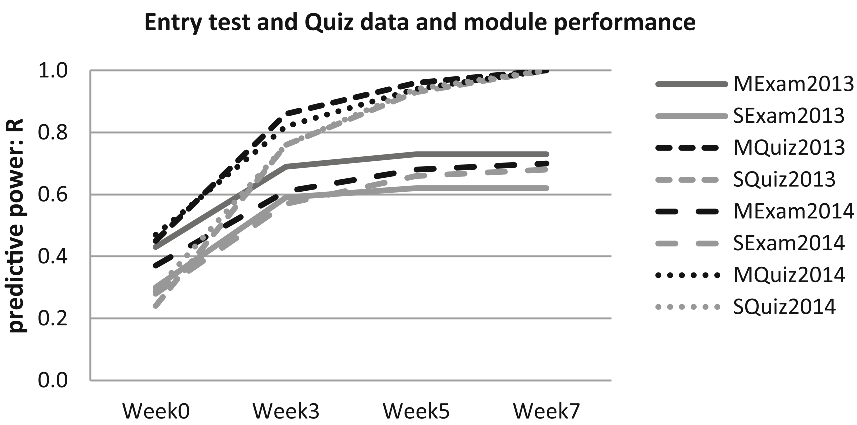

Fig. 3. Predictive power of EntryTest and Quiz data for six performance measures.

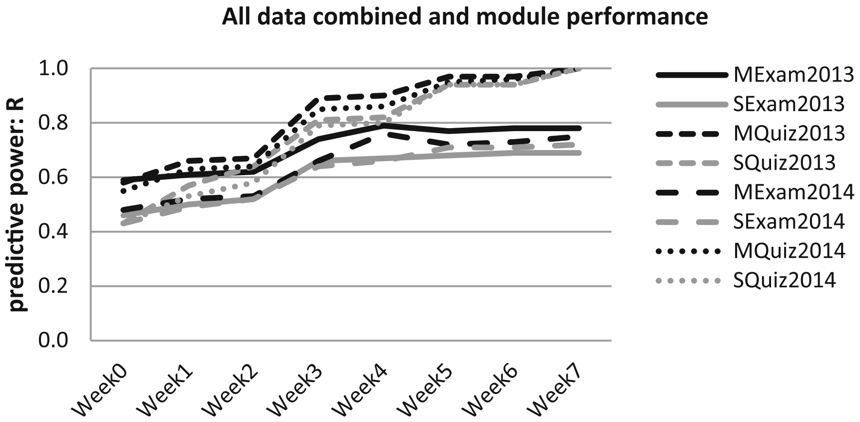

Fig. 4. Predictive power of all data combined for six performance measures.

4.4 Predictive Power Per Cohort

All four figures as well as Table 1 allow for a comparison of prediction accuracy between cohorts which enable us to find an answer to the second and third research question: stability and sensitivity of prediction models. Stability follows from the strong similarities between 2013 and 2014 outcomes. The pattern reported in the previous section, with strongest predictive power in the quiz data, followed by entry test and e-tutorial track data, and least predictive power in LMS track data, is equally visible for the 2013 cohort, as for the 2014 cohort. Beyond predictive power itself, also the structure of the regression models in the two cohorts (not reported here) demonstrate strong correspondence. However, there is one important exception: prediction accuracy of quizzes in the 2014 cohort, both for mathematics and statistics, is at a much lower level than in the 2013 cohort. It was exactly this exception we expected on the basis of the instructional redesign applied. Breaking the strong link between items available for formative assessment, and items used in quizzing, it was hoped for to take out the strong stimulus to repeatedly practice in the same item pool. Given that the lower predictive power of quiz performance mainly comes from the reduction in the contribution of the MyLab track data, this is exactly what we aimed for in the third research question: the prediction model is sufficiently sensitive to signal the effects of the instructional intervention, aiming to change students' learning behaviour.

4.5 The Role of Learning Feedback Type

Narciss' framework of e-tutorial provided learning feedback [29, 30] distinguishes several types of learning feedback, digital learning environments could provide to learners. Two of these type are available in the MyLab e-tutorials: Sample Problems and Guided Solutions. Sample Problems are worked-out examples, where a complete task is stepwise solved. In the Guided Solutions setup the student solves the task, but in the position of asking for help when a specific step cannot be solved. In the MyLab systems, it is the student who decides what type of feedback is most helpful, and therefore, the counts of the two types of learning feedback in the MyLab track data represent individual learning preferences. In the MyLab tracking data, all Guided Solutions are stored, but Sample Problems only in the last attempt (session) of solving the task. Table 2 contains the correlations of user intensity of Guided Solutions (MLGuided) and Sample Problems (MLSample) with performance data for mathematics (MExam and MQuiz), with other ML track data (MLMastery as the average mastery level in all tasks, MLHours as the total time-on-task, and MLAttempts as the total number of attempts), and with the prior education indicator MathMajor (distinguishing advanced level prior education from intermediate level), in both cohorts (2013 below the diagonal, 2014 above the diagonal).

Table 2. Correlations of performance indicators exam and quiz score mathematics, extended MML track data and the MathMajor dummy, for cohorts 2013 and 2014 (below and above the diagonal, respectively).

2014 2013	M Ex	M Qz	ML Mas	ML Hrs	ML Att	ML Sam	ML Gui	Math Maj
MExam		.68	.40	.03	.12	.01	-.03	.33
MQuiz	.72		.59	.14	.22	.00	.03	.35
MLMastery	.41	.68		.51	.68	.19	.46	.10
MLHours	.02	.20	.51		.45	.13	.31	-.07
MLAttempts	.06	.31	.63	.50		.54	.21	-.07
MLSample	-.12	.06	.43	.35	.19		-.05	-.07
MLGuided	-.12	-.02	.19	.22	.66	-.08		-.11
MathMajor	.43	.39	.16	-.09	-.08	-.14	-.12	

Note: Correlations larger than .06 (.08) in absolute value, are statistically significant at .05 (.01) level.

The next table, Table 3, contains the outcomes of linear regression equations predicting the two performance variables from all MyLab track data, and prior education.

Table 3. Linear regression prediction equations for two performance indicators, exam and quiz score mathematics, with extended MML track data as predictors.

	MExam 2013	MExam 2013	MQuiz 2013	MQuiz 2013	MExam 2014	MExam 2014	MQuiz 2014	MQuiz 2014
MLMastery	.80	.65	.88	.75	.73	.66	.90	.80
MLHours	−.06	−.04	−.08	−.07	−.15	−.12	−.08	−.07
MLAttempts	−.31	−.24	−.06	.21	−.23	−.20	−.31	−.26
MLSample	−.42	−.35	−.30	−.25	−.26	−.22	−.31	−.26
MLGuided	−.11	−.09	−.17	−.16	−.01	−.01	.02	.02
MathMajor		.25		.21		.21		.22

Note: Standardized regression coefficients (beta’s). Beta’s larger than .06 (.08) in absolute value, are statistically significant at .05 (.01) level.

In comparing the two tables, the consistent negative impact of the MyLab use intensity track data (MLHours, MLAttempts, MLSample, MLGuided) in the prediction equations is remarkable, where the pattern of bivariate correlations of these data with the two performance variables is very different: from strongly positive (MLMastery) to insignificant to weakly negative. Another striking aspect is the different roles MLSample and MLGuided take in the prediction equations, where correlation appear to be rather similar. In a multivariate context, with MLMastery as most important covariate, the beta's of MLSample are strongly negative, those of MLGuided weakly negative, or insignificant. The feedback preference for fully worked out examples (in the last session covering the task), for a given mastery level, apparently negatively effects performance in exam and quiz. In comparing the two cohorts, we see the effect diminished as a result of the instructional redesign with regard exam performance.

5 Discussion and Conclusion

In this empirical study into predictive modelling of student performance, we investigated several different data sources to explore the potential of generating informative feedback for students and teachers using learning analytics: data from registration systems, entry test data, students' learning dispositions, BlackBoard tracking data, tracking data from two e-tutorial systems, and data from systems for formative, computer assisted assessments. In line with recommendations by [9] we collected both dynamic, longitudinal user data and semi-static data, such as prior education. We corroborate our finding in previous research [1] that the role of BlackBoard track data in predicting student performance is dominated by the predictive power of any of the other data components, implying that in applications with such rich data available, BlackBoard data have no added value in predicting performance and signalling underperforming students. This seems to confirm initial findings reported in [10], that simple clicking behaviour in a LMS is at best a poor proxy for actual user-behaviour of students.

Data extracted from the testing mode of the MyLab systems, the quiz data, dominate in a similar respect all other data, including data generated by the practicing mode of MyLabs, indicating the predictive power of "true" assessment data (even if it comes from assessments that are more of formative, than summative type). However, assessment data is typically delayed data [37, 38], not available before midterm, or as in our case, the third week of the module. Up to the moment this richest data component becomes available, entry test data and the combination of mastery data and use intensity data generated by the e-tutorial systems are a second best alternative for true assessment data. This links well with [8], where it was found that performance on initial assessments during the first parts of online modules were substantial predictors for final exam performance.

A similar conclusion can be drawn regarding the learning disposition data: up to the moment that assessment data become available, they serve a unique role in predicting student performance and signalling underperformance beyond system track data of the e-tutorials. From the moment that computer assisted, formative assessment data become available, their predictive power is dominated by that of performance in those formative assessments. Dispositions data are not as easily collected as system tracking data from LMSs or e-tutorial systems [20]. The answer to the question if the effort to collect dispositional data is worthwhile (or not), is therefore strongly dependent on when richer (assessment) data becomes available, and the need for timely signalling of underperformance. If timely feedback is required, the combination of data extracted from e-tutorials, both in practicing and test modes, and learning disposition data suggests being the best mix to serve learning analytics applications. In contrast to [9], where no consistent patterns were found in two blended modules using learning analytics, we did find that our mix of various LMS data allowed us to accurately predict academic performance, both from a static and dynamic perspective. The inclusion of extensive usage of computer-assisted tests might explain part of this difference, as well as more fine-grained learning disposition data allowed us to model the learning patterns from the start of the module.

The inclusion of two different cohorts in this study allows the investigation of two additional crucial issues: that of stability and sensitivity of prediction models. Evidence of both was found. Both findings profit from the availability of a very broad set of predictor variables, that proof to be complementary in predicting performance. Being complementary implies that the collinearity in the set of predictors is limited. This limited collinearity contributes to stability; within a set of predictors that demonstrate stronger collinearity, prediction models will tend to be more context dependent, less stable over different contexts, such as cohorts. The broad spectrum of predictor variables does also explain the sensitivity of the prediction model to changes in the instructional design. Without the inclusion of e-tutorial track data, our LA based prediction model would not have been able to signal the change in the construction of quizzes. Thus, a broad set of complementary predictor variables is crucial in the successful application of LA.

Now that we gained more insight in the stability and sensitivity aspects, another aspect emerges for further development and future research: that of feedback and intervention. Feedback is informative if two conditions are satisfied: it is predictive, and allows for intervention. Feedback based on prior education may be strongly predictive, but is certainly incapable of designing interventions as to eliminate the foreseen cause of underperformance [37, 38]. Feedback related to learning dispositions, such as signalling suboptimal learning strategies [39], or inappropriate learning regulation [40], is generally open to interventions to improve the learning process [28, 41]. Feedback related to suboptimal use of e-tutorials shares that position: both predictive, and open for intervention. The requirement of a broad and complementary set of predictors thus needs a completion: that of enabling intervention. On the basis of this requirement, our future research will focus on the generation of different types and different formats of learning feedback, and the sensitivity for and preference of students for these alternative feedback options. Next, learning analytic tools would then serve the role of facilitating the provision of personalized learning feedback. In the last section of the Results described above, a first example of such personalization is suggested. When completely left to the preferences of the student, not all students tend to use the best type of feedback. Given that stored counts of the use of worked-out-examples refer to the last session, one would imagine that using the feedback of Guided Solutions, or even the independent solving of the task, represent a more appropriate learning strategy. Inclusion of such metacognitive feedback is a next step.

For future research, it would be extremely relevant to determine which feedback interventions are relevant for which type of learner. In terms of learning emotions, it is widely acknowledged that interventions (e.g., positive supportive feedback on completing a specific task) which might be potential useful for students with strong anxieties on mathematics may encourage boredom or a-motivation for students with strong mathematics skills who might need different times of interventions (e.g., well done solving that task, but can you crack this mathematics problem that only 2 % of the cohort could solve last year?). While learning analytics research has made substantial progress in predicting academic performance, the real proof of the pudding will be whether powerful, just-in-time personalised feedback can be provided for each type of learner present in our higher education context.

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References

1. Tempelaar, D.T., Rienties, B., Giesbers, B.: In Search for the most informative data for feedback generation: learning analytics in a data-rich context. Comput. Hum. Behav. **47**, 157–167 (2015)
2. Bienkowski, M., Feng, M., Means, B.: Enhancing teaching and learning through educational data mining and learning analytics: an issue brief. US Department of Education, Office of Educational Technology, pp. 1–57 (2012)
3. Siemens, G., Dawson, S., Lynch, G.: Improving the quality of productivity of the higher education sector: policy and strategy for systems-level deployment of learning analytics. Society for Learning Analytics Research (2013). http://solaresearch.org/Policy_Strategy_Analytics.pdf
4. Tobarra, L., Robles-Gómez, A., Ros, S., Hernández, R., Caminero, A.C.: Analyzing the students' behavior and relevant topics in virtual learning communities. Comput. Hum. Behav. **31**, 659–669 (2014)
5. Greller, W., Drachsler, H.: Translating learning into numbers: a generic framework for learning analytics. J. Educ. Technol. Soc. **15**(3), 42–57 (2012)
6. Stiles, R.J.: Understanding and managing the risks of analytics in higher education: a guide. In: Educause (2012)
7. Siemens, G.: Learning analytics: the emergence of a discipline. Am. Behav. Sci. **57**(10), 1380–1400 (2013)
8. Wolff, A., Zdrahal, Z., Nikolov, A., Pantucek, M.: Improving retention: predicting at-risk students by analysing clicking behaviour in a virtual learning environment. In: Suthers, D., Verbert, K. (eds.) Proceedings of the 3rd International Conference on Learning Analytics and Knowledge, pp. 145–149. ACM, New York (2013)
9. Agudo-Peregrina, Á.F., Iglesias-Pradas, S., Conde-González, M.Á., Hernández-García, Á.: Can we predict success from log data in VLEs? Classification of interactions for learning analytics and their relation with performance in VLE-supported F2F and online learning. Comput. Hum. Behav. **31**, 542–550 (2014)

10. Macfadyen, L.P., Dawson, S.: Mining LMS data to develop an “early warning system” for educators: a proof of concept. Comput. Educ. **54**(2), 588–599 (2010)
11. Tempelaar, D.T., Heck, A., Cuypers, H., van der Kooij, H., van de Vrie, E.: Formative assessment and learning analytics. In: Suthers, D., Verbert, K. (eds.) Proceedings of the 3rd International Conference on Learning Analytics and Knowledge, pp. 205–209. ACM, New York (2013)
12. Tempelaar, D.T., Kuperus, B., Cuypers, H., Van der Kooij, H., Van de Vrie, E., Heck, A.: The role of digital, formative testing in e-learning for mathematics: a case study in The Netherlands. Univ. Knowl. Soc. J. UoC **9**(1), 92–114 (2012). In: “Mathematical e-learning” [online dossier]
13. Arbaugh, J.B.: System, scholar, or students? Which most influences online MBA course effectiveness? J. Comput. Assist. Learn. **30**, 349–362 (2014)
14. Richardson, J.T.E.: The attainment of white and ethnic minority students in distance education. Assess. Eval. High. Educ. **37**(4), 393–408 (2012)
15. Tempelaar, D.T., Niculescu, A., Rienties, B., Giesbers, B., Gijselaers, W.H.: How achievement emotions impact students’ decisions for online learning, and what precedes those emotions. Internet High. Educ. **15**(3), 161–169 (2012)
16. Verbert, K., Manouselis, N., Drachsler, H., Duval, E.: Dataset-driven research to support learning and knowledge analytics. J. Educ. Technol. Soc. **15**(3), 133–148 (2012)
17. Baker, R.: Data mining for education. Int. Encycl. Educ. **7**, 112–118 (2010)
18. Thakur, G., Olama, M.M., McNair, W., Sukumar, S.R., Studham, S.: Towards adaptive educational assessments: predicting student performance using temporal stability and data analytics in learning management systems. In: Proceedings 20th ACM SIGKDD Conference on Knowledge Discovery and Data Mining. ACCESS, New York City, NY (2014)
19. Tempelaar, D.T., Rienties, B., Giesbers, B.: Computer assisted, formative assessment and dispositional learning analytics in learning mathematics and statistics. In: Kalz, M., Ras, E. (eds.) CAA 2014. CCIS, vol. 439, pp. 67–78. Springer, Heidelberg (2014)
20. Buckingham Shum, S., Deakin Crick, R.: Learning dispositions and transferable competencies: pedagogy, modelling and learning analytics. In: Proceedings LAK2012: 2nd International Conference on Learning Analytics and Knowledge, pp. 92–101. ACM Press, New York (2012)
21. Rienties, B., Tempelaar, D.T., Giesbers, B., Segers, M., Gijselaers, W.H.: A dynamic analysis of social interaction in computer mediated communication; a preference for autonomous learning. Interact. Learn. Environ. **22**(5), 631–648 (2012)
22. Järvelä, S., Hurme, T., Järvenoja, H.: Self-regulation and motivation in computer-supported collaborative learning environments. In: Ludvigson, S., Lund, A., Rasmussen, I., Säljö, R. (eds.) Learning Across Sites: New Tools, Infrastructure and Practices, pp. 330–345. Routledge, New York (2011)
23. Nistor, N., Baltes, B., Dascălu, M., Mihăilă, D., Smeaton, G., Trăuşan-Matu, Ş.: Participation in virtual academic communities of practice under the influence of technology acceptance and community factors. A learning analytics application. Comput. Hum. Behav. **34**, 339–344 (2014)
24. Rienties, B., Alden Rivers, B.: Measuring and understanding learner emotions: evidence and prospects. learning analytics review 1, Learning Analytics Community Exchange (LACE) (2014). http://www.laceproject.eu/learning-analytics-review/measuring-and-understanding-learner-emotions/
25. Buckingham Shum, S., Ferguson, R.: Social learning analytics. J. Educ. Technol. Soc. **15**(3), 3–26 (2012)
26. Vermunt, J.D.: Metacognitive, cognitive and affective aspects of learning styles and strategies: a phenomenographic analysis. High. Educ. **31**, 25–50 (1996)

27. Martin, A.J.: Examining a multidimensional model of student motivation and engagement using a construct validation approach. Br. J. Educ. Psychol. **77**(2), 413–440 (2007)
28. Pekrun, R., Goetz, T., Frenzel, A.C., Barchfeld, P., Perry, R.P.: Measuring emotions in students' learning and performance: the achievement emotions questionnaire (AEQ). Contemp. Educ. Psychol. **36**(1), 36–48 (2011)
29. Narciss, S.: Feedback strategies for interactive learning tasks. In: Spector, J.M., Merrill, M. D., van Merrienboer, J.J.G., Driscoll, M.P. (eds.) Handbook of Research on Educational Communications and Technology, 3rd edn, pp. 125–144. Lawrence Erlbaum Associates, Mahaw (2008)
30. Narciss, S., Huth, K.: Fostering achievement and motivation with bug-related tutoring feedback in a computer-based training for written subtraction. Learn. Instr. **16**(4), 310–322 (2006)
31. Marks, R.B., Sibley, S.D., Arbaugh, J.B.: A structural equation model of predictors for effective online learning. J. Manag. Educ. **29**(4), 531–563 (2005)
32. Lajoie, S.P., Azevedo, R.: Teaching and learning in technology-rich environments. In: Alexander, P., Winne, P. (eds.) Handbook of Educational Psychology, 2nd edn, pp. 803–821. Erlbaum, Mahwah (2006)
33. Rienties, B., Tempelaar, D.T., Van den Bossche, P., Gijselaers, W.H., Segers, M.: The role of academic motivation in computer-supported collaborative learning. Comput. Hum. Behav. **25**(6), 1195–1206 (2009)
34. Schmidt, H.G., Van Der Molen, H.T., Te Winkel, W.W.R., Wijnen, W.H.F.W.: Constructivist, problem-based learning does work: a meta-analysis of curricular comparisons involving a single medical school. Educ. Psychol. **44**(4), 227–249 (2009)
35. Tempelaar, D.T., Rienties, B., Giesbers, B.: Who profits most from blended learning? Industr. High. Educ. **23**(4), 285–292 (2009)
36. Clow, D.: An overview of learning analytics. Teach. High. Educ. **18**(6), 683–695 (2013)
37. Boud, D., Falchikov, N.: Aligning assessment with long-term learning. Assess. Eval. High. Educ. **31**(4), 399–413 (2006)
38. Whitelock, D., Twiner, A., Richardson, J.T.E., Field, D., Pulman, S.: OpenEssayist: a supply and demand learning analytics tool for drafting academic essays. In: Proceedings of the 4th International Conference on Learning Analytics and Knowledge, pp. 208–212. ACM, New York (2015)
39. Hommes, J., Rienties, B., de Grave, W., Bos, G., Schuwirth, L., Scherpbier, A.: Visualising the invisible: a network approach to reveal the informal social side of student learning. Adv. Health Sci. Educ. **17**(5), 743–757 (2012)
40. Rienties, B., Cross, S., Zdrahal, Z.: Implementing a learning analytics intervention and evaluation framework: what works? In: Motidyang, B., Butson, R. (eds.) Big Data and Learning Analytics in Higher Education. Springer, Berlin (2015)
41. Lehmann, T., Hähnlein, I., Ifenthaler, D.: Cognitive, metacognitive and motivational perspectives on preflection in self-regulated online learning. Comput. Hum. Behav. **32**, 313–323 (2014)

Gamification Behind the Scenes

Designing a Software Engineering Course

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Abstract. Creating a blended and open learning environment that supports self-directed learning is a desirable achievement. However, the difficulty of moving away from a guided, grade-based, exam-cramming teaching style has been shown to be demotivating for students and it is still unclear, how to design the on-boarding process well. We show that the current design of a course, despite being perceived as difficult, leads to mostly positive attitudes towards most aspects of the course across virtually all students. The success is a consequence of applying an evidence-based framework that takes into account two dimensions as guides in the design process: incorporating gamification factors and creating room for learner types. The paper describes how the framework is used during design decisions. Comparing the analysis for individual forum use and peer-reviews on team blogs elucidates why the former is perceived less favorably than the latter and provides insight into potential improvements.

Keywords: Blended learning · Problem based learning · Software engineering · Education · Ecosystem of learning · Self-directed learning · Gamification · Scaffolding · Self-directed learning

1 Introduction

Creating a blended and open learning environment that supports self-directed learning is a desirable achievement. The path of moving from a teaching directed to a more open learning environment can be demotivating for students. It is still unclear, how to design the on-boarding stage for this change. The work presented here builds on several years of research addressing this question.

This paper and the corresponding course design is the result of a series of evaluations and adjustments after gamifying a course in Software Engineering in 2012. The gamified version of the course, builds on mastery and autonomy. Both are different from traditional classrooms, where a single exam results in a grade and not necessarily mastery of the subject and teacher driven content often does not

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leave too much room for autonomy. A course that insists on mastery of the material (repeated hand-ins until perfection) and self-driven learning is difficult because firstly, it is so different from anything previously seen in teaching and secondly, the rate of learning appears to slow down even while enhancing long-term retention ([1]; p. 421). The first experience with a gamified version of the course resulted in a lack of acceptance by students and exposed the mismatch with student motivators, geared solely towards grade and efficient learning to the test due to time constraints. Explicit gamification was perceived as inappropriate for the serious business of study in this culture [2]. The need for an adaptive environment geared towards different learner types and scaffolding during onboarding was also shown in previous work [3]. The result of continuous adjustments to the course have led to a framework for design guidelines for the on-boarding process that takes into account two dimensions as guides in the design process: incorporating gamification factors and creating room for learner types. We show that the current design of a course, despite its content and form being perceived as difficult, leads to mostly positive attitudes towards most aspects of the course across virtually all students. Two elements of the course are analyzed separately: Peer-reviews on team blogs and e-portfolios on a forum. These are the critical elements of the course that have caused problems in the past.

Not only are autonomy and mastery difficult for students, but they are difficult to implement for a single teacher with around 100 students. It would mean giving feedback to homework on a weekly basis. To afford this feedback loop, peer reviews are introduced into the classroom. Peer-Reviews are motivated on several levels, helping the teacher in large classes and helping the students learn the material by becoming the critical teacher. However, peer reviews are the source of a plethora of new challenges that surfaced as they became popular as a method of grading in large scale settings of MOOCS. According to [4], having studied Coursera MOOCs in detail, aspects of peer review (incentive, presenting complex scores back to students, assigning reviewers) are still open research problems. Studies look at how accurately the peer grade reflects the expert teacher grade in order to justify peer review as student grade. Some studies show the difficulty that peer reviews pose to students from the feeling of power to not understanding their use. According to one study, professionalism is lacking, loyalty to fellow students interferes and inadequate effort is apparent because it is not required [5]. In line with these findings, in a previous version of this course, peer reviews have been shown to be a difficult component and were simply neglected by students. As a result, they were not appreciated for their potential usefulness.

Platform adaptation and scaffolding through extrinsic motivation changed this in our course. (In this paper, adaptation relates to the fact that students choose their own environment. There are currently no system-based adaptive learning platforms available to us.) Peer reviews were made public on platforms (usually blogs) that are chosen and controlled by students. The importance of modern social platforms in communication and learning reflects studies by several researchers [6–9]. The completion of peer reviews is recorded and figures directly into the final grade, thereby creating an immediate incentive as a scaffolding device. With these changes, autonomy through defining their own environment and project and mastery through reworking homework based on peer feedback now show a clear and immediate connection to the final grade. The purpose is a final handin for the teacher, who is the only one assigning a grade.

Equally not well understood is the use of a forum in the classroom. Their use has been explored specifically in the context of MOOCs. Surprising to the instructors is the lack of use of forum compared to the large number of students enrolled in MOOCs. This was noted both by MIT's edx course [10] as well as Stanford's analysis of Coursera classes [11]. A slightly higher participation is reported by Vanderbilt, explained in part through an integration with completion criteria [12]. The use of forum is to share knowledge across locations, in our case across classrooms. The forum is a place to find the knowledge that a student needs in order to do the homework in a timely and efficient manner. The larger a student body, the easier it is to find the necessary information without posting. In a small setting (of 90 students) there may never be enough information to make it useful, especially, since it is difficult to appreciate the importance of sharing information, which takes extra time but is a prerequisite for receiving information as a time saver. In agreement with other research results establishing forum participation is difficult for this course.

We explain how the framework is used to design these course elements and with student feedback use it to reevaluate design decisions. Creating a framework to guide the design of the onboarding process is an iterative process. Through continuously gathering evidence of success and problem areas rationale to both students and faculty to renovate learning environments is provided.

The paper is structured as follows. After a review of the theoretical background in gamification and learner types used for this work, Section 3 describes the current course setting and design. Sections 4 and 5 describe the use of the framework for these two components of the course design. Section 6 summarizes the results of a survey polling students' perception of the course components. Section 7 reflects on the results using the framework as guideline. We conclude with thoughts about future directions for this work.

2 Design Framework

Based on previous work, a Software Engineering course has been redesigned over the course of three years from a guided project- and exam-based frontal lecture course to a non-scaffolded gamified learner-driven version [2] and finally a scaffolded blended learning environment that caters to a variety of learner types [3,13]. These three forms represent a pendulum between two extremes and coming to rest in the middle in what we call an onboarding stage. The adjustments have been made to match student motivation [14] by integrating gamification factors and catering to various learner types [15]. These two dimensions of the design framework will be reviewed in this section.

2.1 Gamification Elements

There are implicit elements to the course that are motivated by gamification and the underlying motivational theory of Pink's universal motivators: Mastery, Autonomy and Relatedness or Purpose [16]. In particular the vocabulary from gaming is used to think of the course as an onboarding process designed as player journey [17], also emphasized in J.Taggs work on scaffolding [18]. In the language of gaming, Points, Badges and Levels are comparable to the traditional form of grading students. A slow transition to intrinsic motivation akin to mastery and autonomy is accomplished by weaning students off the cheap scaffolding reward system, leading towards learning as the key accomplishment. (see also Self-determination theory Ryan Deci [19,20]). From this work, the list of design factors given in Table 1 is used (see also [14] for more details). The external motivation factors represent the most common attributes of addictive games. There is a large list of additional gamification factors that are less universal. While the course uses gamification principles, the vocabulary is not used during teaching due to cultural aspects [2].

Table 1. Hidden gamification factors.

	Mechanics
External	Aesthetics
Motivators	Progress Bar
Platform	Immediate Feedback
	Leaderboards
	PBL (Points, Levels, Badges)
Internal	Autonomy
Motivators	Mastery
Classroom	Purpose
	Basic Needs (Maslow [21])

2.2 Gamer Types

According to Susan A. Santo [22], there is no generally accepted definition for learning styles despite the fact that many different learning style models exist. For the purpose of this work, Grasha's definition of a learning style as somebody's preferred way of learning ([23,24]) is sufficient because they are validated as stereotypes in an iterative approach to understanding subgroups of students usage of platform functionality [15]. According to the Grasha-Riechmann Student Learning Style Scales, there are six styles that can be differentiated amongst learners as given in Table 2.

Grashas theoretical definition of these six learner-stereotypes was used to derive an exaggerated e-platform usage pattern for each. Because students do not match stereotypes, usage patterns become evident in the degree to which

Table 2. Learner types.

Learner Type	Description
Participant	The learner is very interested in the course content and asks questions.
Avoidant	The avoidant learner works as little as possible or only shortly before a dead-line.
Independent	The learner works on his/her own and rarely asks for help.
Dependent	The learner needs lots of support and detailed instruction.
Collaborative	The learner prefers working in a team.
Competitive	The learner wants to do better than other course participants.

a student matches a combination of these pure definitions. Previous research has shown that learner types are visible through the way that the students use the learning platform [15]. Looking at user behavior and preferences on platforms allows us to partition users into subgroups of patterns combining the stereotypes. An example such constellation in one year of teaching consisted of three major subgroups exhibiting patterns of competitive (10 %), avoidant (38 %), and participant-collaborative (28 %) learner types, while the rest of the students did not have a clear user profile. While it may be astonishing that there are so few competitive students, the three groups roughly represent the three personas that can be casually observed in a classroom.

3 Course Background and Setup

The subject of this study is a Software Engineering course. In order to understand under which circumstance the teaching/learning takes place, the desired learning outcomes by society are described as well as the setting of the course within the Bachelor program at the Cooperative State University in Karlsruhe. Finally, the course content and design are described.

3.1 Course Setting

Each year around 90 students, split into three classes, are the participants in the study by taking the mandatory Software Engineering course in their second year (out of three) during their Bachelor program at the Cooperative State University. The academic year is based on a quarter system. Students spend alternating quarters studying or working while earning a salary throughout the year. Their attendance at University is mandatory and they study in cohorts. As students are required to remain within their cohort in order to graduate, failing a course may easily result in the failure of the entire Bachelor degree and preclude further study in that subject area in this University system. The combination of quarter system and a fixed six semesters towards a Bachelor degree results in students spending more than 5 h a day and sometimes up to 25 h per week in frontal lectures in the same classroom that is equipped with the classic wooden chairs, desks, blackboard and projector. 15 min breaks mornings and afternoons and a lunch break in the middle of the day round up the program. Evenings and weekends are spent with project work. From the teacher perspective, full-time lecturers can be in the classroom over 20 h a week, including courses outside of their immediate expertise. Other lecturers teach on the side while working in industry. Both students and lecturers work under intense time and performance pressures. There are no teaching assistants available for teachers.

3.2 Desired Learning Outcome

Students have never before been responsible for their own learning beyond what is needed to perform well on an exam in a traditional setting. Neither in school nor at the University has self-regulated learning been explored, a situation that may have been exacerbated by the standardizing Bologna reform. However, there are necessary reasons for changing the learning environment away from the frontal lecture from employers, students and University points of view.

From the employer point of view, it is important to move students from a check-box based approach to obtaining good grades to a mastery based approach, which is more aligned with workplace demands. Whereas in school (including University), handing in something to be graded on a certain date may count as a completed task, industry work environment expects several passes through a piece of work until perfected. While one might think that behavior can be adapted based on environment, employers report that key reasons for not hiring students include their lack of transfer skills, lack of critical reflection on own performance and lack of soft-skills. Top desired skills apart from practical know-how are team skills and capability for self-driven learning. Industry expectations of Bachelors were met 63 % of the time in 2011. By 2015 this number had reduced to 47 %! Only 16 % of those questioned would agree that the students have been well prepared for industry [25,26]. 80 % of participants in the poll are either working with the cooperative Bachelor model or planning to integrate it, thereby making the constrained ecosystem described here the new norm.

From the student point of view, reasons for changing the format of coursework are threefold: First, the number of hours spent listening to lectures can be decreased by letting students work independently towards pre-defined goals, thereby becoming more actively involved in the learning process. Second, with up to 25 weekly hours of frontal lecture, a self-determined format may be perceived as a nice change of pace. Finally, due to the noticeable difference in know-how between students and even between lecturer and student (working inside the fast-moving IT industry), there is an advantage to leaving space to learn from each other or proceed according to a personal profile gap between knowledge and desired skill set.

The Universitys reasons include knowledge of research results about positive learning outcomes when creating a more active and problem based learning environment [27,28] despite the fear of change [29]. Key reasons for change include the overwhelming variety of high-quality information sources that are available on the web. With the most current appearance of MOOCs (Massively Open Online Courses) from some of the top Universities in the US, standards for frontal lectures are set, including written transcripts of what was said, the ability to rewind and re-listen to any lecture any time and communicating with an active global community. Increasingly, excellent information is available via Youtube and Internet outside of any systematic courses as students are relying less and less on books to acquire knowledge in the rapidly changing field of Information Technology. Even from one year of teaching to the next, there can be profound changes in technology that a set frontal lecture would not be able to cover in a practical manner.

3.3 Course Content

Topics covered in this Software Engineering course are structured into three pillars of three topics each: Software development (Design Patterns, Metrics, Testing), Communication (Requirements Specification, Effort Estimation, Reverse Engineering) and Project Management (Processes, Configuration Management, Lifecycle Management) and culminates in a project-based experience. This approach gives students enough time to learn all aspects of Software Engineering before applying the collective know-how in a project. The chosen topics are typical for Software Engineering courses as evident also in current course books [30]. The material is taught in a project-based manner. There are theoretical lectures and associated homework that is applied to each team project.

3.4 Course Design

Students are asked to define their own software projects and determine their team for the duration of the course, which lasts two quarters. Each week, there is one lecture and one homework that relates directly to the lecture and the project. This homework is posted on the groups' chosen platform and design (mostly blogs). According to set criteria, the homework is then peer reviewed by any group across all three classrooms. In previous versions of this course, students work, submissions and peer reviews as well as forums were located on a single MOOC platform, chosen by the instructor. The most significant complaint in the past was dominated by a criticism of the infrastructure and lack of useful feedback by other students. The most significant change for this instance of the course was the student choice of platform and the public peer evaluations that had to be shown to the instructor to gain points towards the final grade in the course. The students were in complete charge of their platform. In the past, peer reviews were private and not taken seriously by all students; all reviews are now publicly displayed with group name and their publication under the control of the blog owner.

Autonomy is expressed through self-determination when choosing a project, the technology to realize the project and choosing a team. The key difference in student perception of the course consisted in extending the autonomy to the platform for displaying student work in public and hosting peer reviews. The scaffolding consists of providing deadlines for set homework, evaluation criteria and enforcing the use of public peer reviews on student blogs and including this work as part of a grade.

Mastery is realized by delaying the grading on content until submissions undergo several reviews and revisions, creating a peer pressure towards excellence in the public forums. Through the use of peer reviews, guidelines for evaluation and reflecting on their own homework, final understanding of the course material is supported.

Blended learning environment consists of 4 h of in-class time and virtual extension of the classroom through the online activities described above. Each week a lecture is given that covers exactly one new aspect that relates to the next step required in the project. The subsequent week, some of the groups present the homework in class and receive feedback from the teacher. This feedback is then often used when giving peer reviews to other project homework, propagating the information to other groups. This approach blends live feedback by a teacher with peer reviews. Homework is then revised and has often been rechecked by peers to verify the correctness of the change (this point was not required by the instructor). Since each team has the same homework but applies it to different projects, cheating is impossible and helping or "copying" (such as documentation method, presentation style, tools to use, etc.) from each other is encouraged. The schedule for topics and peer reviews in given in Table 3.

While the general guidelines for homework and projects are given, the specific technical implementation is not prescribed. As an example, students are required to use an MVC framework to build a web application and the lecture focuses on the principles of the Model View Controller architectural pattern. The programming language and chosen framework for its realization is optional. As a result, Laravel (PHP), Rails (Ruby) or Django (Python) enter into the classroom. Principles of their use are reviewed by peers and presented as homework in the classroom, broadening the course with student-built content. Lecture is then usually followed by in-class peer review sessions and project work as time permits. 2 peer reviews were required by each team each week. Completing the peer reviews included answering peer reviews with a feedback about its usefulness. Both had to be shown to the teacher to obtain points that counted 30 % towards the final grade.

In addition to the team work, individual grades are given for individual contributions bringing students expertise to the classroom with topics that are related to the course content. These are called e-Portfolios and their successful completion consists of an online tutorial on a topic and a hands-on presentation and exercise to be done in class. The result is posted in a Forum. Over the years this content is built up to support incoming students with tutorials on topics that are directly related to the course. Not all students present on topics relating directly to the homework that is due that week of the course because there are 90 students and roughly 20 topics. Students can present new technology or other software engineering related topics that are of interest to them but not necessarily related to the homework that week.

The forum that was used in this course was chosen with several aspects in mind. It has to be a free, remotely hosted, easy-to-use, modern platform that is freely accessible, preferable with a mobile view or app, easily configurable by the teacher to take into account feedback from students and customizable by students. Forum posts need to be easy to view and update from a student or teacher perspective. The chosen forum is modern popular platform that is used in many settings in- and outside of educational setting.

The grading scheme combines personal (20 %) and team effort(80 %). Out of 80 % the team component, the final project counts for 50 % of the grade (Split into an oral presentation (20 %) and the written hand in (80 %)). Progressing towards the final submission in regular intervals is tied into the grade by by awarding points with each peer review for a total of 30 %.

4 Design of Peer Reviews on Blogs

Peer reviews on student blogs are designed using the framework in order to align this part of the course with student motivation. Table 4 describes how each of the user types will be addressed with the classroom setup for peer reviews.

Table 3. Schedule of peer reviews.

Week	Topic
1	Find your team and set up the blog
2	Define your project and roles for team members
3	Software Requirement Specification with overall use case diagram
4	5 Use Case Specifications with activity diagrams, mockup, (deferring description)
5	Adding description to use cases using Gherkin .feature files as machine readable business language
6	Create MS Project using Rational Unified Process terminology
7	Define MVC tool and software architecture for project
8	Use scrumboard for regular iterations
9	Define change management
10	Proof of running cucumber
Semester Break (3 Months)	
1	Risk list and risk management plan
2	Commitment to 3 functional use cases as basis for this semester
3	Function point calculation for use case estimation
4	Proof of refactoring
5	Design pattern explanation and refactoring of code to include chosen design pattern
6	Proof of test code and coverage measurement
7	Proof of metrics tool run automatically on code
8-9	nothing
10	Proof of installation for transition of software

The gamification factors are realized on the platform and in the classroom as follows during the design phase:

Aesthetics: Teams chose their own platform (usually) blogs and designs.
Progress Bar: Each week points are collected for peer-reviews that count towards the grade.
Feedback: Feedback to homework is publicly visible and immediate (within a couple of days).
Leaderboards: Blogs can be liked, and there were popular blogs for "cool" projects.
PBL: Points are collected each week for the peer review; badges and levels do not exist.

Table 4. Learner types in peer review setting.

Learner Type	Description
Participant	The participant is happy to create their own blog space and share their fantastic ideas and get cudos from their fellow classmates.
Avoidant	The avoidant is forced to participate.
Independent	The independent type is able to create their own way of participating in the class.
Dependent	The strict schedule helps the dependent learner
Collaborative	Giving feedback to others and working together to put on the next blog entry helps the collaborative type to feel comfortable.
Competitive	The competitive users can show off their entries on the blog as well as the postive public feedback to their work.

Table 5. Learner types in e-Portfolio and forum setting.

Learner Type	Description
Participant	The participant will be happy to post on the forum and share knowledge. They are also happy to "like" someone else's entry.
Avoidant	The avoidants will be happy to find the answer to their homework on the forum.
Independent	The independents is happy because part of their grade depends on their own effort and wants to follow their own ideas about software engineering - it they get points for giving a presentation about that, all the better.
Dependent	The dependents is allowed to work with a partner of their choice for a longer presentation.
Collaborative	The collaborative user likes to share information and look at what others have contributed in a forum.
Competitive	The competitive user controls their grade in this way, can show off their know-how in front of class and get points. The competitive user cares about the stars and the awards system on the forum.

Autonomy: There is no autonomy in homework assignments neither in content, nor in schedule, nor in review criteria. There is autonomy in how to display the information on the blog and who to review. The lack of autonomy is due to scaffolding and habit - building.
Mastery: Mastery is encouraged through feedback from peer review before being graded on same criteria by teacher. Blogs display evidence of iterating over solutions until the reviewers (co-students) are happy.
Purpose: The purpose is to obtain a homework that can achieve a high grade at the end of the semester.
Basic Needs: Students have complete control over the grade. 2 Points are given by the teacher when 2 reviews are submitted and 2 are received and answered. But students are not graded by fellow students. The final grade is given by the teacher at the end of the semester following the same review criteria that was used by the students.

5 Design of e-Portfolios on the Forum

e-Portfolio contributions on forums are designed using the framework in order to align this part of the course with student motivation. Table 5 describes how each of the user types are addressed with the classroom setup. The gamification factors were taken into account as follows during the design phase:
Aesthetics: The forum is a public website that provides free forum access, and presents a very typical forum view. By choosing an open source platform students will be used to the interface. Several skins were provided to the students so that they could personalize their forum views.
Progress Bar: The contribution of the e-portfolio is integrated into the grading process. By finishing this component early, a significant part of the grade is secured.
Feedback: Immediate feedback is given by the teacher on the forum and by students in the classroom. The topics are chosen from the student's interest and should be of general interest to the classroom.
Leaderboards: There was no plugin for leaderboards in the forum.
PBL: Level-up meter and an award system plug-in were installed on the forum. Points are given for logging into the forum and with each additional entries into the forum stars are presented to the user. A symbol for award of full points achieved is awarded by the teacher when the e-portfolio is complete. The students know they have received full points on that part of the course.
Autonomy: The student is free to schedule his personal contribution at any time over the course of two semesters.
Mastery: There is one presentation to the class which is submitted to the forum for the benefit of the other courses in parallel or for the next years. Further hand-ins are sample code and a tutorial. The badge for completion is only given once all articles are submitted and mastery achieved.
Purpose: To achieve 20 % of the grade relating to the personal contribution.
Basic Needs: Control by the students over their own grade that grants them independence from project and team.

6 Evaluation Survey

The purpose of this survey is to determine the student contentment with their learning environment given the described circumstances. The expectation is to find that diverse learner types feel comfortable with the course. The second motivation for the survey was to better understand the on-boarding process. It is important that the students do not perceive the learning environment as threatening, which has been shown to happen in the non-scaffolded version of the course [2]. Finally, the result should be a repeatable process over several classrooms.

6.1 Description of Survey

Students were asked a variety of questions regarding the entire setup of the course (designed with reliability and validity in mind [31]). The questions were mainly categorized into the areas under study: e-Porfolio, Forum, Blog, Peer Reviews and self-determination regarding the project and technology (see Appendix 1 for the complete list). 81 students are surveyed towards the end of the first semester within the span of one week in three different classrooms of 27, 23, and 31 students each. Because three classes were taught in parallel, it was possible to calculate agreement of results across cohorts. Students were asked to evaluate their experience on a 4-point Likert scale (avoiding the middle value to get a clear tendency) from agree completely to disagree completely regarding the tools. The questions were very simple and designed to be closed-ended for comparison. To compensate, the final section of the survey allowed students free text to express their thoughts on difficulties and a different setup of the classrooms. The described survey contains additional components pertaining to learner types. It can be shown that feedback is mostly independent of learner types, which was the goal of the design and in stark contrast to the original version of the course that showed large discrepancies in acceptance between groups of students [14]. Analysis across learner types is discussed in detail in [13].

6.2 Results

Results from the ratings for the questions are mostly positive. Figure 1 depicts 2,5 minus average scores for each of the questions. Bars going to the right show tendency to agree with a positive statement about a course aspect. Bars pointing to the left show disagreement. The 90 % confidence interval for the results is plotted within the graph. Table 6 lists the correlation factor between classes for each of the different subtopics in the questionnaire. We are looking for both agreement and high ratings.

Most aspects of the course receive favorable feedback across all three classes in a reproducible manner. This outcome was the goal of the course design and such a result can not be taken for granted [14]. All students agree that autonomy in choosing their own technology and projects is important. However, other key results are important to highlight for further adjustment of the course design. First, while acceptance of the other aspects is generally positive the forum platform stands out as it is rated low across all groups. Second, Class 1 has a consistently less positive

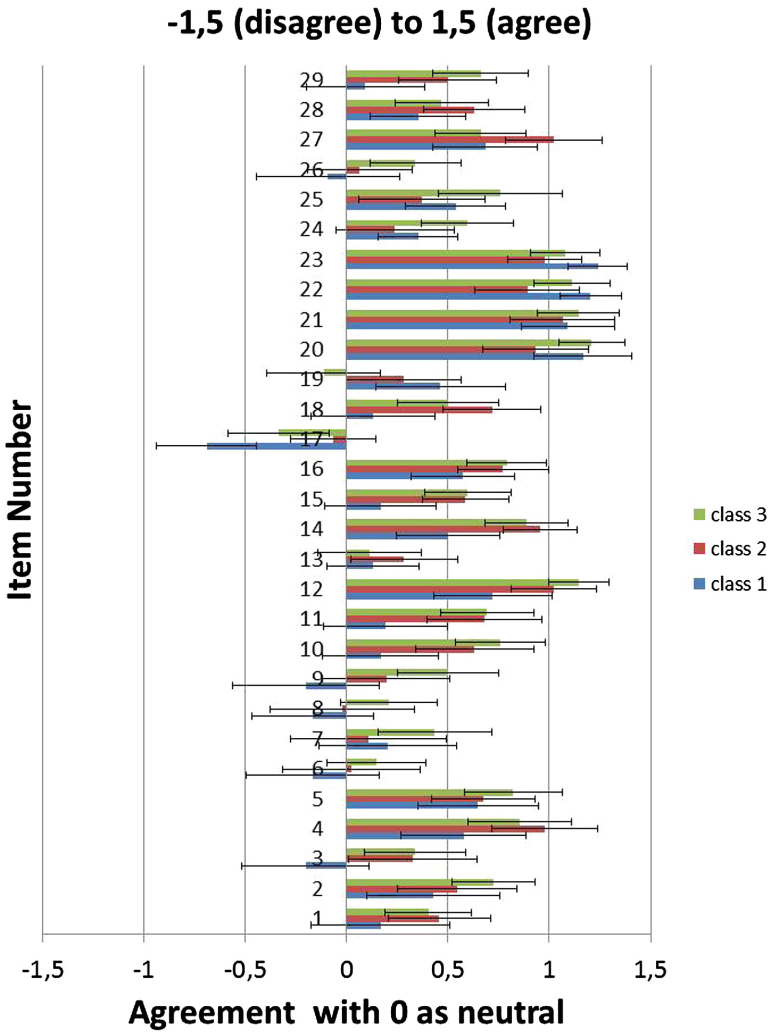

Fig. 1. 2,5 minus average scores depicting agreement between three classrooms within 90 % confidence interval (denoted). The numbers on the y-axis refer to question items given in Appendix 1.

Table 6. Agreement between classrooms on survey questions.

Correlation	Class 1/2	Class 1/3	Class 2/3
Peer	0,83	0,96	0,91
Blog	0,98	0,99	0,95
Self-Direction	0,96	0,96	0,97
e-Porfolio	0,75	0,68	0,97
Forum	0,97	0,60	0,77

opinion than the other two. Yet, there are only a few points where the difference is significant. The biggest disagreement in correlation between classes (Table 6) is in the area regarding forum and e-Portfolios. 6 out of the 10 significant differences in opinion (Figure 1) are in the area of forum and e-Portfolio as listed below. (Notice that point 19 is a negative statement). At 95 % confidence, only point 17 *Forum is a good place to share this information* remains on the list.

- #3: Giving feedback helps me to understand material
- #9: I like to create our blog for the project
- #10: I like to share my work with the others
- #11: I look forward to receiving feedback
- #eP14: I like that my interests are incorporated
- #eP15: I am interested in peer expertise
- #eP17: Forum is a good place to share this information
- #eP18: e-Porfolio of others are interesting for me (if I had the time)
- #eP19: I dont have time to be interested in ePorfolios
- #F29: The ePlatforms for this course are functional

We were able to show that peer reviews are difficult but accessible with scaffolding and modern social platforms. After the first rounds of difficulty, students understand the impact that peer reviews have on their motivation of obtaining a good grade. Positive interactions regarding peer reviews were visible on several blogs during the first and second semesters, final feedback from students at the end of the second semester were positive [13].

The use of other elements (such as Forum, e-Portfolio) of the blended course have been less successful without the necessary scaffolding. Using the framework from Section 2 the differences between these two components of the course and their setup can be described to gain understanding of the lack of acceptance of the forum.

Table 7. Learner types in e-Portfolio and forum setting.

Learner Type	Description
Participant	The participant learner was probably addressed.
Avoidant	The avoidant learner was lost because scaffolding regarding committing to a date is needed here and will be implemented. If it is true that there can be 38 % of this type of learner in a classroom (see Section 2.2 [15]) then a significant number of students' motivation is lost here.
Independent	The independent learner was probably addressed but might have presented e-portfolios that are less relevant to immediate homework making this part irrelevant for other class members. Setting limits to the freedom of choice in topics will be necessary.
Dependent	The dependent learner is probably addressed by allowing team work in a few cases.
Collaborative	The collaborative learner was probably addressed.
Competitive	The competitive learner was probably addressed.

7 Reflection on e-Portfolios on the Forum

The survey showed that there is general content with the course. While there are some issues with timing and clarity of content, the overall framework was accepted by students even though the course is perceived as very challenging both in content and format. It was shown that the same feedback can be reproduced across three different classrooms. Forum and e-Portfolio were less well scaffolded than peer reviews and were reviewed less positive and with less agreement between students. Adjustments to the e-Portfolio management are still required. Using the framework yields some insights and limitations into progressing forward in this area according to Tables 7 and 8. Rethinking the points given student feedback reveals the misconceptions for various categories at the outset of the course design.

Table 8. Aspects of forum improvement.

	Mechanics	Realisation
External Motivators Platform	Aesthetics	Theoretically, the forum fulfills this criteria. However, students did not feel that the forum looked good and found them difficult to use for finding information. To improve this point, forum topics should be aligned with homework assignments to help find information. Signing in to the forum, explaining how to use it, giving in-class time to choose their own look and feel may seem superfluous but may be an important scaffolding step to warm up to the platform.
	Progress Bar	Gradual use of the forum in the classroom could provide a sort of progress bar. The stars that are obtained for certain actions like logging in, creating a profile or a calender entry for their e-portfolio presentation can be steps that are explicitly taken as a class.
	Feedback	The content of the e-Portfolio should be more closely tied to the homework so that there is a need to have an e-Portfolio that is useful to the other students in the classrooms. Feedback comes from other students who found the content useful. This will be especially useful in the coming year, when the forum is being used for the second time and already contains relevant entries from the previous classes.
	Leaderboards	It takes time to build up “likes” for certain well written forum entries. By the time, students from successive years realize that a blog entry is well done, the author may well have graduated and pay no more attention to this entry or their status. There is also no leaderboard plug-in so this component is still difficult to redesign. One could ask students to rate the e-portfolio directly after the presentation by giving a “like” for relevance to the class and general interests.

Table 8. (Continued)

	Mechanics	Realisation
	PBL	While the badge was tied into the grade, stars can be given for certain activities and do not count towards grade nor prestige but are part of receiving the badge.
Internal Motivators Classroom	Autonomy	While the student was free to choose topic and time of the presentation, this will be more closely monitored to align with classroom content. Dates for presentations will be handed out by week 4 of each semester at the cost of giving the student the opportunity to find out their own interest over the course of the semester(s).
	Mastery	Mastery has been addressed.
	Purpose	The purpose was simply to receive that part of the grade. Perhaps by joining a more public forum, prestige can be redefined more widely, similarly to stack-overflow forums. PBL's are predefined but have meaning outside of the classroom. This may interfere with the time pressure of students and their basic needs.
	Basic Needs	Basic needs are better met by aligning the topic more with the course content schedule.

8 Future Work

Future work will show how e-portolios and forum can be better integrated, perhaps across years and not classrooms, where one class provides information that is appreciated by subsequent years. This in turn may motivate those students to provide more information to students in lower years. The time-gap between effort and profit is much larger. One might consider linking into online forums like computer science stackexchange (http://cs.stackexchange.com/) but this does not change the fundamental problem with immediacy and basic needs. The difficulty remains to turn extrinsic rewards like grades into intrinsic rewards of knowledge building and sharing even if they have no impact on the points/badges/levels system of the old-school grading system [19]. Mastering this kind of attitude toward working together however, is a skill that will be much appreciated by industry.

In future, course survey questions should be much more aligned with the proposed framework for evaluation. Designing these questions well is an iterative process that changes with increasing knowledge of the learning environment one creates. It would be desirable to test the framework on other courses and on larger student bodies or replicate this course at another University. Cultural aspects are very important to take into account. One thing seems sure though, the lack of time is a key factor driving student behavior that can not be neglected in any course design, regardless of culture. Therefore, the restricted ecosystem under which this course was realized is unfortunately the (new) norm.

Appendix

Table 9 lists all items of the questionnaire used to evaluate the onboarding process for Software Engineering based on principles of gamification with blended learning.

Table 9. Hidden gamification factors.

Peer Reviews On a scale of 1:agree completely to 4:disagree completely rate the following:
1P: Interaction with other teams is important
2P: I like to see what the others are working on
3P: Giving feedback helps me to understand material
4P: Receiving feedback helps understand material
5P: It helps me to improve my grade
6P: It helps me keep my time schedule
7P: It is good that the activity counts toward my grade
8P: It is interesting
Blog On a scale of 1:agree completely to 4:disagree completely rate the following:
9B: I like to create our blog for the project
10B: I like to share my work with the others
11B: I look forward to receiving feedback
12B: I like to help others with what I know
e-Portfolio On a scale of 1:agree completely to 4:disagree completely rate the following:
13eP: I like to influence the topics in this course
14eP: I like that my interests are incorporated
15eP: I am interested in peer expertise
16eP: I like to share my know-how with peers
17eP: Forum is a good place to share this information
18eP: e-Porfolio of others are interesting for me (if I had the time)
19eP: I dont have time to be interested in ePorfolios
Self Determination On a scale of 1:agree completely to 4:disagree completely rate the following:
20S: I like to define my own project
21S: I like to define my own technology
22S: I like to work in a team
23S: It is important to have control over my grade
24S: I feel that I can influence my grade
25S: The content of this course is relevant for my work
Forum Platform - Classroom On a scale of 1:agree completely to 4:disagree completely rate the following:
26F: I prefer asking my peers to tutorials in the web
27F: I prefer interacting in the classroom to virtual
28F: I like to work with peers to create knowledge
29F: The ePlatforms for this course are functional

References

1. Bjork, R.A., Dunlosky, J., Kornell, N.: Self-regulated learning: beliefs, techniques, and illusions. Annu. Rev. Psychol. **64**, 417–444 (2013)
2. Berkling, K., Thomas, C.: Gamification of a software engineering course-and a detailed analysis of the factors that lead to it's failure. Submitted to ICL 2013. In: 2013 International Conference on Interactive Collaborative Learning (ICL), vol. 42, pp. 525–530 (2013)
3. Thomas, C., Berkling, K.: Redesign of a gamified software engineering course. In: 2013 International Conference on Interactive Collaborative Learning (ICL), pp. 778–786 (2013)
4. Piech, C., Huang, J., Chen, Z., Do, C., Ng, A., Koller, D.: Tuned models of peer assessment in MOOCs (2013). arXiv preprint arXiv:1307.2579
5. Nilson, L.B.: Helping students help each other: making peer feedback more valuable. Essays Teach. Excellence **14**, 1–2 (2002)
6. Thomas, H.: Learning spaces, learning environments and the dis 'placement' of learning. Br. J. Educ. Technol. **41**, 502–511 (2010)
7. Aydin, S.: A review of research on Facebook as an educational environment. Educ. Technol. Res. Dev. **60**, 1093–1106 (2012)
8. Tinmaz, H.: Social networking websites as an innovative framework for connectivism. Contemp. Educ. Technol. **3**, 234–245 (2012)
9. Pujo, F.A., Sánchez, J.L., García, J., Mora, H., Jimeno, A.: Blogs: a learning tool proposal for an audiovisual engineering course. In: 2011 IEEE Global Engineering Education Conference (EDUCON), pp. 871–874 (2011)
10. Breslow, L., Pritchard, D.E., DeBoer, J., Stump, G.S., Ho, A.D., Seaton, D.T.: Studying learning in the worldwide classroom: research into edX's first MOOC. Res. Pract. Assess. **8**, 13–25 (2013)
11. Manning, J.: How widely used are MOOC forums? A first look (2013)
12. Bruff, D.: Lessons learned from Vanderbilt's first MOOCs (2013)
13. Berkling, K.: Connecting peer reviews with student motivation - onboarding, motivation and blended learning. In: 7th International Conference on Computer Supported Education (CSEDU) (2015)
14. Berkling, K., Zundel, A.: Understanding the challenges of introducing self-driven blended learning in a restrictive ecosystem-step 1 for change management: understanding student motivation. In: 5th International Conference on Computer Supported Education (CSEDU), pp. 311–320 (2013)
15. Berkling, K., Thomas, C.: Looking for usage patterns in e-learning platforms - a step towards adaptive environments. In: 6th International Conference on Computer Supported Education (CSEDU) (2014)
16. Pink, D.H.: Summaries, soundview executive book: the surprising truth about what motivates us. Soundview executive book summaries (2010)
17. Kim, A.J.: Smart gamification: designing the player journey, 16 February 2011
18. Tagg, J.: The Learning Paradigm College. Anker Publishing Company, Bolton (2003)
19. Ryan, R.M., Deci, E.L.: Intrinsic and extrinsic motivations: classic definitions and new directions. Contemp. Educ. Psychol. **25**, 54–67 (2000)
20. Gagné, M., Deci, E.L.: Self-determination theory and work motivation. J. Organ. Behav. **26**, 331–362 (2005)
21. Maslow, A.H.: A theory of human motivation. Psychol. Rev. **50**, 370 (1943)

22. Santo, S.A.: Relationships between learning styles and online learning. Perform. Improv. Q. **19**, 73–88 (2006)
23. Grasha, A.F.: A matter of style: the teacher as expert, formal authority, personal model, facilitator, and delegator. Coll. Teach. **42**, 142–149 (1994)
24. Fuhrmann, B.S., Grasha, A.F.: A Practical Handbook for College Teachers. Little Brown & Co., Boston (1983)
25. Heikaus, O., Flasdick, J.: Kompetent und praxisnah - Erwartungen der Wirtschaft an Hochschulabsolventen (2015)
26. Heidenreich, K.: Erwartungen der Wirtschaft an Hochschulabsolventen (2011)
27. Goel, S., Sharda, N.: What Do Engineers Want? Examining Engineering Education through Bloom's Taxonomy, Online Submission (2004)
28. Garrison, D.R., Kanuka, H.: Blended learning: uncovering its transformative potential in higher education. Internet High. Educ. **7**, 95–105 (2004)
29. Hall, S.R., Waitz, I., Brodeu, D.R., Soderholm, D.H., Nasr, R.: Adoption of active learning in a lecture-based engineering class. In: 32nd Annual Frontiers in Education, vol. 1, pp. T2A–9. FIE 2002 (2002)
30. Sommerville, I.: Software Engineering, 9th edn. Pearson, Boston (2011)
31. Schumann, S.: Repräsentative Umfrage: praxisorientierte Einführung in empirische Methoden und statistische Analyseverfahren. Oldenbourg Verlag (2012)

Project-Based Learning Emphasizing Open Resources and Student Ideation: How to Raise Student Awareness of IPR?

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Abstract. This article examines a project-based course that is based on the use of open resources, where students ideate and implement Open Data applications in small groups during an intensive 12-week period. The course emphasizes students' abilities to innovate and necessitates the adoption of technologies that are typically new to the students. The course is offered at the bachelor's level after highly structured first university courses, which means that the students face a great challenge with regards to adopting self-directed and self-regulated way of working. The main research focus of the article is on how to emphasize Intellectual Property Rights (IPRs) as a learning objective. In the project education literature, IPRs are typically discussed in conjunction with courses where students collaborate with external customers. We argue that the present Open Data context together with creative group work also require a proper emphasis on IPR questions. A project agreement template and educational activities are designed and proposed to be used in student-ideated projects to properly raise student awareness of IPRs.

Keywords: Project-based learning · Open resources · Open data · Innovation ability · Creativity · Intellectual property

1 Introduction

'Project method' has existed in education for almost (or at least) a century, as indicated by Kilpatrick's [36] early report. Project courses in the field of computer science and software engineering have also been implemented for decades [49], with a high number of reports published over the decades. Within these fields, various project course models have emerged and are summarized in taxonomic reports by Shaw and Tomayko [44], Fincher et al. [19], Clear et al. [11], and Burge and Gannood [7]. As reflected in these reports, an educator can choose from a number of course attributes when designing a project course. Generally, project education reflects the educational thinking that 'function drives the form' [19], i.e., the educational goals for a project can be reached by selecting applicable course attributes.

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Recent course conceptualizations include teamwork in multicultural [42] and multidisciplinary [8,25] settings. Accordingly, it should be fairly plausible to state that project education reflects changes in the modern working life environment. The present article describes and reviews a bachelor-level project course where *students innovate* a software product using 'Open Data and open APIs (Application Programming Interfaces)', which are on the increase among societal interfaces. This course theme was initially regarded as topical and, therefore, potentially interesting to students, while making projects realistic and hence educationally relevant at the bachelor's level. Innovation ability is a skill that many agree is important for present-day and future graduate students [18,56,57].

The authors' previous *CSEDU2015* article [31] described the course concept and several challenges observed in running the course after two course iterations. These challenges require careful planning to be followed by informed action-taking during the next instance of the course. The present article extends upon the previous article by addressing one of the challenges described in detail, that is, how to emphasize IPR as a learning objective during the course.

IPR questions during project courses are typically acknowledged and formally managed in projects where students collaborate with customers (industry) (e.g. [51]). The customer interface is typically managed through agreements or contracts between individual students, customers, and the university (e.g. [53]). In the present article, we propose project agreements to be used also in the setting where external customers are not used but rather students themselves ideate the products. We design a project agreement template and educational activities needed to raise IPR as a learning objective.

Section 2 reviews the theme of 'openness' while Sect. 3 makes remarks on how IPRs show in project course reports. The course concept is outlined in Sect. 4, while Sect. 5 describes the IPR challenge faced by teacher and students in detail. The challenge is then addressed in Sect. 6, where actions needed to emphasize IPRs as a learning topic are designed. This section reflects planning for subsequent action-taking in the authors' action research project that aims to address the challenges identified during preliminary course iterations. Concluding remarks are stated in Sect. 7.

2 Being 'Open' in the Digital Era

When a resource is open, it is available for others to use. It is freely accessible, usable, modifiable, and redistributable as-is or as a derived work. Similarly, an open activity or process can be followed and affected by others during its execution. However, when the attribute of openness is attached to different things, we end up with multifaceted and varying conceptualizations, such as open data, open source software, open service, open innovation, open education, open information society, open government, open science and research, etc. (see, e.g., [32]). To be known as open, a resource or outcome of a process is typically attached with an open license. For a piece of software, this can mean complete freedom, even to close the derivative works, as with the permissive MIT license.

Another well-known alternative is to enforce the derivative works to be similarly available as the original source code, as with the copyleft GPL licenses (see [50] and references therein).

Open *data* is accessible and usable for further processing and refinement. According to [16]: 'Open data is the concept that defines the publication of government or private company data without copyright restrictions. The data should be formatted so that citizens can reuse it at their discretion to create new, innovative services or applications.' However, the overall rights for even a raw data resource should be governed by a content license, such as one from the creative commons family[1]. Moreover, open (and sometimes big) data is often not enough, but one should be able to turn it into interesting patterns, models, and visualizations [23] that provide answers to some specific questions of true value [24]. In the Finnish national context, the development of the open data movement has been summarized by [33].

Recently, many tools and methods for utilizing open data have been proposed: visual exploration of open data [41], a flexible environment for Web data integration [9], a domain-specific language (DSL) for open data visualizations over the Web [40], and a high level library to help developers build safe mashups over APIs in HTML5 [48], to mention a few. Open data can also be utilized in existing or novel games, as suggested by [20]. Concerning the Semantic Web tools, the integrated knowledge base of open data is referred to as the Linked Open Data (LOD) (see [3] and articles therein). Arguably, such massive data sources increase complexity of applications but also their potential benefits.

Activities to create, publish, and utilize open data are becoming more and more popular. In many cases, availability of open data can be linked to an open innovation process fostering collaboration between private companies (especially in the creative industry), governmental or public actors, citizens, and academia (scholars and students), once again to create new products and services through purposive inflows and outflows of existing or newly created knowledge (e.g., [12,27]). The existence of a local co-creative platform can be an important precondition for publishing some existing data, even if to reach the actual innovative outcomes requires continuous efforts and allocation of time from all the participants.

It should be noted that to be able to be innovative may require a basic understanding of the actual term innovation, which, for undergraduate students, could be challenging [18]. Similarly, as argued by [13], scientific inquiries related to open innovation reveal a lack of clarity regarding the term's meaning, especially in the business context. However, the paradigm of open innovation has been proposed by [10], with the encouragement of knowledge inflow and outflow to ensure that tasks are completed efficiently and effectively. He sees open innovation as the key to developing novel products and services in the modern business world. He proposes six principles to achieve open innovation, two of which are relevant here: (1) work with smart people inside and outside the company (university

[1] https://creativecommons.org/licenses/.

students of CS should qualify), and (2) a firm (or a student team) does not have to originate the research (or data and software) to profit from it.

The innovation process and outcome can be closed or open. For instance, an open source software component can come from a private software company taking part in the open source development. Similarly, the user-centric design process of, for example, texture for a new curtain model, might end up as a new product sold under a (closed) trademark. As educators in the digital era, we should inform students about making the outcomes of their Open Data/API projects open [27]. So far, the main focus of the course studied in this article has been inbound open innovation, i.e., utilization of existing open resources to produce an own software deliverable.

3 IPR in Project-Based Courses

Allocation of IPR is formally managed in project courses where students collaborate with customers, with many papers reporting similar arrangements. The basic argument on these courses is that it would be difficult to devise relevant customer-ideated projects, and hence to collaborate with real customers, if IPRs are not granted to customers, as is illustrated by the survey data by Warnick and Todd [54]. The typical arrangement is that students grant IPRs to the customer; this occurs through written agreements or contracts [2,26,30,51–53]. Due to university contracting polices, this may in practice be managed so that students grant IPRs to the university who then signs it off to the customer (e.g. [22]).

Many courses allow students to select whether to work in a customer project that requires the transfer of IPR to the customer or in a customer project which do not necessitate an IPR transfer [2,30,51–53]. The experiences reported by scholars indicate that students are typically willing to transfer the IPRs and that only few students object or select other options (e.g. [26,52]). However, it seems that the position of students who object is not always addressed. For instance, Stearns et al. [46] note that they had no process defined for those who objected (and did not sign to) the transfer of IPR and that these students 'just continued' in the capstone sequence.

The characteristics of the customer, university polices, and stance taken by educators may also affect how the customer interface and the IPRs therein are realized. A quite common scenario is that customers who are granted IPR are also charged for the projects, the payment being directed to the university and spent on the costs arising from running the course—which applies to the real customer projects at the authors' department [30]. A panel paper [55] reports on an arrangement where a customer who is required to actively attend the project does not pay but is granted IPRs. Leidig and Lange [38] in turn note that, while IPR is granted to their course customers, the university should prepare for after-project technical support due to collaborating with non-profit organizations, regardless that such customers initially agree on resource limitations. Doepker [15] reports on the arrangement where customers are granted IPR, but the university shares in the potential profits emerging from the projects.

The present interest in IPR concerns student projects that are based on the students' own ideation without a customer stakeholder. Interestingly, a 'call for' tackling IPR in such contexts is acknowledged, but no explicit solutions on how this should be done were found in the literature through non-systematic searches. In a study describing an open innovation contest, Abdelkafu [1] reports on how students may not be willing to submit their work due to being concerned about IPR. In a game development course that exemplifies creative pedagogy, Kiili et al. [35] also identify the presence of IPR issues, and mention the need to tackle them.

We argue that granting IPR to the customer in real customer projects provides, in a sense, an educationally straightforward solution, as students do not need to consider how much each individual actually contributed—IPR is granted to the customer anyway. In student-ideated projects, IPR questions may occupy students' minds more due to the presence of attributes such as creativity. Accordingly, Bach et al. [4] describe the open innovation setting as being dispersed when compared to traditional IPR protections that are more focused in nature.

To emphasize the educational need for addressing IPR issues in the course based on openness, it should be noted that students tend to feel ownership over their work even when they work as 'executors' [45]. Further, as noted by Fuller et al. [21], students as well as software developers may be willing to rashly use software regardless of licensing violations, but be much more strict when considering ownership of their own programming contributions. For our purposes, we would reformulate this remark such that the use of available open resources with own deliverables can create tension when own achievements are overemphasized, resulting in licensing violations.

We also briefly observed literature outside project-based courses. A framework and an implementation of a local open innovation project platform named "Demola" was described in [34]. A mutually beneficial and agreeable IPR model was nominated as one success factor for such projects by multidisciplinary MSc level student teams that produced new products and proof-of-concepts together with companies. The Demola IPR agreement protects the rights of the original authors, giving partner companies full utilization rights but, surprisingly, 'Software licenses from the open source perspective are not addressed in the IPR agreement' (p. 299). Moreover, the paper reports on a small survey on IPR issues, which was issued to project groups and replied to by nine people; the responses indicated that only little care was being given to such matters in the actual projects. This was concluded to be a significant risk, indicating a slight knowledge gap (IPR in principle and in practice) as well.

Based on the outcomes of an European ITEA2-project, eight core practices for software innovation in software companies were suggested in [43]. In addition to being able to stimulate innovation, harvest and valuate ideas, support expertise (etc.), a software company innovation practice referred to as "the Art of Openness" was depicted. Interestingly, the paper mentioned that the utilization of open source software is in many cases not even recognized at the CEO level in companies, whereas the actual development confronts it frequently. The suggestion made was to define an openness strategy at each relevant level of operation: product, process, organization, and business model.

Altogether, we find it pedagogically appealing to be able to integrate IPR issues in the project course in two senses: first, to face the issue when searching and innovating with available open resources and, second, to deal with the issue in the applied sense when agreeing on the rights of the team deliverables.

4 The Course

This section summarizes the relevant attributes in the implementation of the course. The presentation reflects the current state of the course design, while IPR related actions are reflected on and re-designed in Sects. 5 and 6.

4.1 Workload, Learning Objectives and Facilities

The project course spans 12 weeks and students are rewarded with 5 ECTS credits. The course is intensive and challenging; the software product prototypes illustrating at least a proof of concept are ideated and implemented in the given time frame through newly formed groups.

The initial learning objectives were to introduce and conceptualize group processes and software process issues to the students through realistic project work at the bachelor level. After two course iterations, these objectives were complemented with the ones emerging from the innovation-based course concept; that is, prompting self-directed study processes among the students and improving student self-efficacy. Related to the possibility of improving self-efficacy, ideating and producing software from scratch sets a technical learning goal for the students. These latter kinds of learning objectives were the main focus of the author's *CSEDU 2015* article [31]. The present article focusing on how to address IPR during the course emphasizes IPR as an important learning objective.

Each group is provided with a lockable work room equipped with personal computers for each student to support students' realistic and autonomous work. The course thus differs from studio-based learning environments where students' work is guided through fixed practice sessions (see, e.g. [47]). The faculty's PC support is available to the students, and they are granted local administrative rights to install and configure software independently. Typically, programming code is managed in a version control system, and each student pulling from the remote repository can run the needed server applications in the local computer (localhost). The intended group size is four students, though, due to course population, a few groups have also comprised 3 or 5 students.

4.2 Teaching Resources

The course is taught by two supervisors. A departmental teacher (the first author) supports students with group work issues and software process issues, while a senior student works as a technical supervisor. The senior student recruitment is based on a strong personal interest in the course topic (creative software development based on the open theme).

Absorbing the overall architectural idea of how to work with APIs and integrate data and software components into new products is important for the students. It is this competence that the technical supervisor of the course needs to possess. Many API releases are supported with an open source wrapper code. Then, what remains as a task of the programmer, in order to receive the data needed, is studying, integrating, and potentially modifying the wrapper. Similarly, parsing various data formats used in open data and API context, such as JSON, is often an effortless task, while open source components also tend to exist for parsing less popular data formats such as PC-Axis. In light of these examples, students are to be informed of the *conventions* and existing *technological possibilities* of small-scale open source (web) development. The technical supervisor, attending all the per group supervision sessions, importantly facilitates the students' technology adoption process.

The aim is to develop a course climate where the personnel reflect strong interests in their specific expertise areas, to inspire students to develop professional interest in the course topics. In our experience, the course has been manageable for two persons with up to 7–8 groups and a maximum of four students in each.

4.3 Joint Course Events

The course structure is displayed in Fig. 1. The top line describes events concerning all the students. The course begins with a start-up meeting during which the course idea, course events, and documentation are explained to the students. This meeting also provides students an introduction to Open Data and APIs, by giving examples of the related applications found on the Web and a comprehensive list of open resources. Both national and international (EU) open data and API links are listed, and known services with API releases, such as Spotify, Twitter, Bibsonomy, and Trello, are noted. To enable students to picture about the scope of their project, exemplary resources are discussed through speculative examples ("Trello could be complemented with a component that first exports users' work hours markings and then imports a sum of them with visualization"). Students are also guided to independently seek other fresh data releases based on their own interests. They are also told that HTML scraping could be needed to receive data within the interesting topic. Students are grouped by the teacher at the start-up meeting. Because the course pedagogically focuses on group work issues, the aim is to group student who have not worked together previously. This way each group's dynamic has a fresh and equal start.

The next shared event is the project lecture where group work concepts, including norms, statuses, roles [6], and justice in group work [29], are discussed. The topic of software processes is also included. Here, discipline in the software development is carefully explained and linked to project safety. A particular emphasis is also given to iterative software process, which has been found to fit

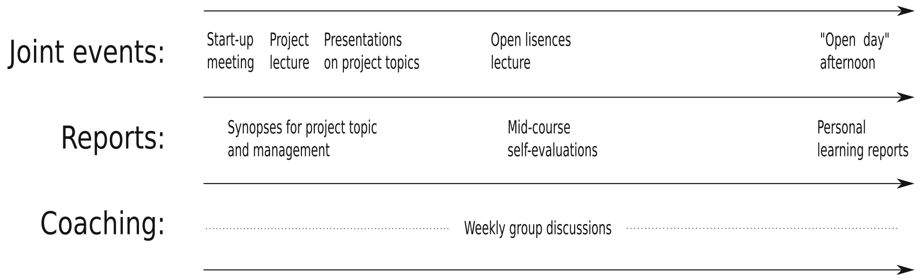

Fig. 1. Course events and tasks during 12-week creative software development effort.

realistic student projects [28]. On the third week, a shared session is arranged where the groups describe the project topics they have ideated. This session is intended to reinforce the innovation theme across groups and share considerations on the use of data resources and the designs of software products. Near mid-course, an expert lecture on open source software licenses is provided to increase student awareness on the licensing issues and enable them to agree on the licensing of the group products.

At the end of the course, groups present their software products during an 'open day' for the department's personnel and other students. In place of traditional presentations, students present in their project rooms and allow the audience to try the software products and discuss design and implementation. This way of presenting fosters dialog among the attendees.

4.4 Minimal but Important Documentation

The mid-line in Fig. 1 describes the documentation required during the course, which is minimal. At the beginning of the course, student groups prepare short synopses for 1) what they have agreed as their project topic and 2) how they are going to manage their work. These are intended to help the students be aware and take responsibility. In the synopsis on the project topic, student groups provide an abstract for the topic but also address the important feasibility questions below:

- further ideas and visions,
- target group (utility aspect),
- licenses and terms of conditions of the intended data usage,
- data formats,
- technical environment (programming languages, platforms, libraries, etc.),
- licensing of the product (under what open source license the product is released), and
- boundaries of the project, i.e., what parts of the ideated project are most relevant and to be achieved during the project.

These questions are reviewed in per group supervision sessions. A potential gray zone in data usage is thus avoided since the students are guided to find out and comment on the conditions of their data usage. Should there be any open questions, these will be naturally raised since the synopsis questions are reviewed. Because student work is by default owned by the students, they naturally decide on the licensing of the products. In the synopsis, groups make an initial agreement on an open source license for their product. The licensing question is later supported by an expert lecture (see Fig. 1), after which the students are prepared to make an informed decision, taking into account the licenses of the used components. In the course based on the students' own ideation, the university does not require any transfer of rights. It must be noted here that the present article refines the educational actions needed for properly emphasizing IPR during the course; see Sects. 5 and 6. For instance, we will raise IPR already at the time of course registration and use per group IPR agreements.

Given the emphasis on the students' own product ideation, the projects are based on the students' proposals with no initial inclusion/exclusion criteria on APIs, data, or application type. For instance, the product can be a web service or a game, as well as a desktop application, and we have also suggested the use of Arduinos and Raspberry Pis in the context of open resources. Students must nevertheless consider a target group, which implies that the projects become realistic as compared to programming exercises with no user interest. The open theme enables small-scale products starting from ones making single data source utilizable through data manipulation and visualization (cf. small tools for data journalism), while often the ideated products are larger. For this reason, student groups prioritize and define boundaries for what they aim to achieve during the project (see synopsis items above). We want to prompt students to be creative, while the synopsis document and weekly supervision discussions help groups set their goals realistically during the project.

At mid-course, self-evaluations on group work and software process are conducted, each student completing a survey form. The teacher inspects the evaluations and raises their main points during a group discussion session; the group situation revealed by the evaluations is openly discussed. When the projects are complete, each student prepares a personal learning report, reflecting on group work and software process issues in light of both lectured theory and conceptualizations that emerged during the project. The teacher gives a written response to each learning report to enhance student learning.

The inclusion of very little documentation means that all tasks are substance tasks that advance the actual ideation and software product development. This makes it almost impossible for students to limit their involvement to completing some secondary tasks; potential 'passenger' roles become visible and can be raised as group issues. For project management, the students use VCSs (with no exceptions, this has been Git) and project management software, such as Trello. It should be noted that limited documentation does not indicate low teacher workload, as sensitive group discussions (Sect. 4.5) are very challenging for supervisors and require preparation and continuous reflection.

4.5 Emphasis on Dialog Through Group Discussions

The bottom line in Fig. 1 illustrates that teaching this course means coaching through group discussions. Thus, a discussion session attended by the course teacher, the technical supervisor, and the student group, is arranged each week for all the groups. The group situation, software process, and various issues in product ideation and implementation are discussed in these sessions. Informal discussions were considered suitable for the creativity-based course, and are a tool to introduce theory in the presence of authentic practical work; emergent problems are contemplated in terms of theory. During a particular session, the written self-evaluations provide the basis of discussion, which aims to guarantee that all the students are heard through personal writings during the project.

In this short course, the main learning objectives are introduced at the beginning through lectures and are then intensively addressed in the group discussion sessions throughout the course in the context of actual individual projects. The main pedagogic principle is based on the realist epistemology [5,39]. Thus, it is based on an assumption that there are important objectifications that can explain to the students their project successes and challenges, and that these objectifications must be raised during the project to foster conceptual understandings among the students. It is important to note that the innovation-based open-themed projects have provided a good forum to introduce truly authentic project work where group issues, for instance, emerge naturally and can be conceptualized to the students realistically. Taking group work as the example case, the pedagogy of the course was described in detail in another study [29]. The solution to the question of how to emphasize IPR issues during to course (in Sect. 6) follows the same pedagogic principle: the process of agreeing on IPR in the open-themed course context is 'conceptualized' to the students (see Fig. 2).

4.6 Pass/Fail Grading

Considering the sensitive issues (e.g., justice in group work) discussed during the course and the aim to promote the students' innovation ability, grading is pass/fail. Without competitive or external pressure of numeric grading, students are prompted to overcome their difficulties in adopting self-directed, creative, learning processes and to fully focus on conceptualizations that explain their group experiences. Positive experiences with a project-based course without numeric grading have been reported by Daniels et al. [14]. Promoting student interest in course content instead of 'just passing the course' is also in line with the Klug's [37] work. He linked (numeric) grading with a degree system that does not necessarily match with the learner's personal intellectual development.

In our course, students track their work hours. However, passing the course is not based on quantitative inspection of student work hours or amount of programming code. These attributes approximate student role in the group, but they do not explain the effect of group situation on the student's possibility to participate. The passing is based on active participation, which is fairly easy for the teacher to interpret with the selected course arrangements: the frequent meetings between the supervisors and groups and the related discussions on group processes. During these discussional sessions, reasons for low participation are objectively addressed in terms of group work processes, following that the students themselves become aware if their difficulties result from group work or if they are truly not participating in the course. In the first case, various solutions for improving the group situation are sought for. For instance, by improving intra-group communication the division of work could be improved to match the skill levels of group members.

On the basis of the exposition above, 'failing' and 'dropping out' can be said to mean same thing in this course. Accordingly, two dropped out students of the course agreed to drop out for low participation which was due to reasons external to the course. It should also be noted that group difficulties do not directly mean dropping out; rather, through active participation the difficulties undergone can be reflected on for the sake of conceptual learning.

5 The Intellectual Property Challenge

This section describes the IPR-related challenges that we have identified in running this course.

5.1 Lack of Systematic Expert Support

At the beginning of the course, when exploring various resources for their work (data, APIs), students encounter a 'jungle of terms of conditions (TOCs)'. This particularly occurs when a student group uses data sources that are 'semi-open' in nature, with some specific and often ambiguous clauses stating the conditions of use. The intention is to act legally. Unclear situations have been currently resolved with the teacher requesting expert comments from department personnel who are known to possess the required expertise. Alternatively, where students have scraped web content, the teacher has guided groups to contact the service providers to request permissions for using the data, which has been a successful procedure. The groups have either received permissions or an answer that has helped them to revise their project goals. Altogether, the IP issues in relation to the utilization of resources have introduced a great challenge, a kind of a delay element from the teaching perspective, as the interpretation of TOCs and various small clauses can require juridic expertise.

5.2 Lack of Support for Informed Decisions

Another important IPR-related challenge concerns the outcomes of group effort. We described in Sect. 4 that students have been asked to initially agree on open licensing at the beginning of the course and decide on the license by the end of the course. We have noticed that students tend to only cursorily comment on the question at the beginning of the project ("we will use some form of open licensing"), as they are only ideating their project. Further, the teachers' impression is that students also make fairly hasty selections at the end of the course, without in-depth, intra-group discussions, and hence there is an educational need to increase dialog on IPR to both allow and foster more informed student involvement. We notice that we have not systematically communicated IPR and 'IPR in connection to openness' to the students, which would most likely explain our experience of IPR as a 'sidetrack' during the course.

5.3 Lack of Proper Release

The IPR challenge during the course is also related to the question of how to release or 'exhibit' project results. An unfavorable pattern can emerge when students overcome their group work and self-direction challenges and show abilities to ideate and implement a product, only to see the completed project as 'just a course assignment' without big-picture relevance. This perspective can leave the course without the purposive outflow of newly created products [27]. Different from our master's level customer project, there is no final release of project deliverables to any customer stakeholder. In addition, in the context of the local CS curriculum, there is no larger business study component underpinning the course that would inspire students to continue with their projects as the course ends. Thus, we need to consider how students should release their results. In our thinking, a meaningful release would increase the perceived relevance of educational discussion and decisions on IPR.

6 Actions for Emphasizing IPR as a Learning Objective

The activities presented below address the challenges described in the previous section. The overall educational purpose is to emphasize to the students that IPR must be raised, discussed, agreed on, and decided on. The agreement template, which is referred to in the text below, was translated from Finnish to English and is provided in Appendix A. The proposed template is tentative and has been briefly commented upon by the Legal Counsel of the University of Jyväskylä. The precise form of the proposed kind of agreement naturally depends on the national legislation (e.g. the general rights for student work outcomes) and on the university level regulations (e.g. who can sign such agreements).

6.1 Before the Course

In a course registration form, we ask if a student is willing to agree on IPR within a group during the course. The student is given the following information on the registration form:

> *Intellectual property emerges on products ideated and implemented in groups during the course. For this reason, it is appropriate that group members agree on how to license project results and thus on after-project use of the results. For this reason, an agreement will be signed during*

the project, which ensures that group members are willing to make an agreement and will select the way of licensing of the results. An example of this procedure is that group members attach open licenses to their project results. The university makes a request that the project results can be used for presentation and education research purposes. Intellectual property rights are not transferred in any way to the university.

We thus inform students at the time of registration that there is a natural need for agreeing on IPR within groups and that the university does not make any claims on IPR. Those students who are not willing to agree on IPR can be advised to take an individual programming project, which is one of the alternatives for a practical 5-credit course in our bachelor offerings. The request by the university is the possibility to use projects for presentation and research purposes, which is a common policy in the department's project courses and relates to the basic tasks of research and societal interaction realized by Finnish universities.

6.2 During the Course

The groups will be provided with a 'consultation hour' from the university jurist or a departmental person with similar expertise to facilitate the interpretation of complex license and TOC texts when ideating with data resources. The project course is one alternative for the mandatory practical study component in the students' bachelor studies, and the responsibility for answering juridic questions that arise during the course naturally rests on the course provider. Having an explicit course arrangement for this purpose would make the start of the course more fluent and underline IPR issues as an important learning objective. Another option would be to guide the students to strictly limit their project ideation to resources whose conditions are phrased without any ambiguities. However, in our view, this latter option would limit how the course concept can foster student innovation ability. Moreover, the use of various data resources and APIs increases both the students' and the supervisors' useful knowledge on intellectual property rights and licenses. For this reason we recommend that the course supervisors also attend the expert consultation hours suggested here.

To be able to emphasize IPR as an important objective, we will use written agreements. During the starting lectures, a project agreement template is reviewed and given to students to be prepared for their particular project. This guarantees that all course students are informed about the agreement's contents. During the first week, the agreement of each group is signed by each student of the group and the university stakeholder. However, as is noted in the agreement template, each student group attaches an appendix describing their selected licensing procedure till the end of the course. Thus, we want student groups to be able to start working from an unambiguous (signed) position where IPR is being addressed, while allowing the selection of actual licensing to take place at the end of the course, when the students can picture about their project outcome and have attended the mid-course expert lecture on open licenses.

When the agreement template is reviewed in the presence of students, a remark is made that students can select regarding their willingness to granting the research and presentation permissions, and that the agreement text is revised accordingly. The template default text informs students on the research to which the requested permission relates, meaning that an attempt is made to follow the national research ethics guidelines.

To increase student awareness of IPR and to allow for informed decision-making, we will also raise IPR as a lectured topic during the starting lectures. Students will be informed of intellectual property in the context of openness using the model in Fig. 2, which is inspired by the discussion on IPR and open creativity by Bach et al. [4]. These authors note the importance of interaction between 'as many entities as possible' in creative processes in contrast to the mere reliance on talented individuals. In line with this remark, we want to illustrate to the students that they act not only as individuals but as a group, which is likely to provide a useful ground for ideation: a project idea initiated by a particular student may go through refinements, additions, and even transformation to new ideas within a group. A student group and the interactions between its members are illustrated in the center of Fig. 2.

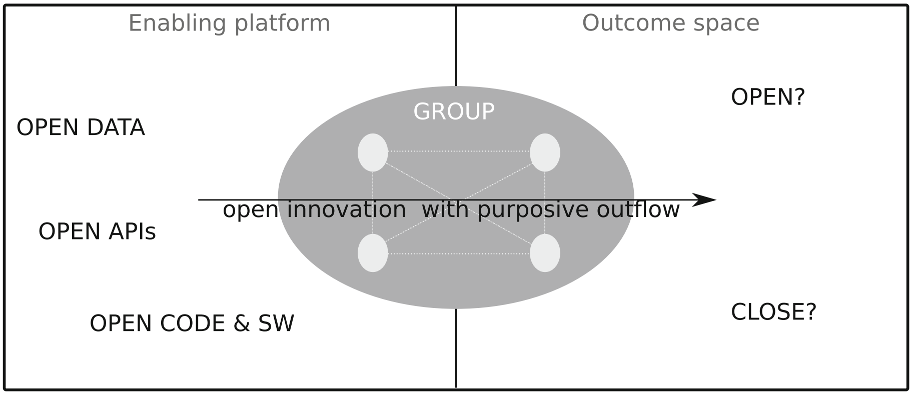

Fig. 2. The open-themed course setting conceptualized for informed IPR agreements within groups.

Another perspective stressed by Bach et al. is that innovations that find their way to commercialization require 'underground' creative communities. The authors note the dilemma between acts to restrict access to creative works and being open to fuel the functioning of creative communities. In this connection, we want students to be aware of the 'communities' involved. The left-hand side in Fig. 2 illustrates that students build open data applications upon open data and open API releases and various open programming code fragments and software components, while also upon the efforts underlying the publication of such resources. Thus, students are provided with an enabling, pre-existing, platform, which is important to be aware of when making decisions on the licensing of project results. As displayed in Fig. 2, we also illustrate the presence of the open innovation process, which emphasizes a purposive outflow and openness of the outcomes. As the university does not make claims on student work, we provide students with the information on openness in a neutral way. It is possible that particular groups consider their project idea suitable for another (closed) way of publication, for which reason we also provide students with information on local area hatcheries and innovation hubs. Accordingly, it is possible that the licensing information attached to the contract is a purely student-specified clause, and even that 'each group member can utilize the project results as they wish'. The minimal educational goal is that IPR were raised, discussed, agreed on, and decided on, and hence acknowledged as an unavoidable topic in goal-oriented creative group effort.

On the question of how to release project results, we establish a showcasing site with links to GitHub or other platforms used by students for their product development. Such a site can then be connected with a local open data community, meaning that student work would become 'involved'. The students are also informed of and encouraged to attend open data contests in Finland (see [17]). The important educational question is how to deal with differences in the maturity of the products, i.e., how students perceive these differences if the products are made publicly available. Here, our plan is to ask student groups to prepare a digital presentation of the project to be included in the showcasing site at the end of the course. Students are hence able to set the form and the level of detail in their presentation.

7 Concluding Remarks

This article described a course concept that builds on student innovation ability, including attributes such as creativity and co-creation. The course is based on the students' use of open data and API releases. The main goal of the article was the designing of activities for emphasizing IPR as a learning objective. In the literature, IPR have typically been addressed in project courses where students work with customers, while in the settings drawing on students' own ideation IPR has received less attention. In this light, the present article can also contribute to other creativity-based education such as game development. The article reflects action research planning activity, which will be followed by action-taking and evaluation.

The educational actions designed stress that students are informed early on that they will make IPR-related agreements during the course and that all agreement template clauses must be reviewed in the presence of the students. Students should also be informed of licensing options and the idea of open innovation before deciding on how to deal with IPR. Further, we also stress that we will provide all information to the students in a neutral way, as the university is not making any IPR claims on the students' work.

Our subsequent action-taking will be evaluated from the perspectives of whether the designed activities raised students' awareness of and interest in

IPR, how students reacted to the activities proposed, and to what extent students, who are objectively informed about IPR and given the full freedom to decide on how to license their results, will adhere to 'openness'. Moreover, it is interesting to study how much students' views on IPR decisions differ within groups.

A Project Agreement Template

Responsibility for potential mistakes rests on the users of the template. The template is open to modification. We have marked with italics obvious replaceable points. For instance, the need for and formulation of the research permission request depends on the students' opinion on granting the permissions.

A.1 Stakeholders and Purpose of the Agreement

This student project agreement (the "Agreement") concerns the study module *TIEA207 Introductory Project in Computing and Technology* (the "Study Module"). The Agreement is made between the *University of Jyväskylä/Department of Mathematical Information Technology* (the "University") and the individual students who participate in the Study Module as an assigned group ("the Group"), implementing a project according to the Study Module syllabus and requirements ("Project"). This Agreement governs the rights to use and redistribute the material that is created by the Project.
The Group consists of the following students: *student names here.*

A.2 Definitions

In this Agreement, unless the context otherwise requires:

"Learning Assignment" refers to a task that must be done to pass the Study Module but whose outcome is not part of the main product of the Project, which is to ideate and implement a software system (including its source code) by the Group. Written Learning Assignments consist of, but are not necessarily limited to, ideating documents and presentation materials, Project management documents, time allocation reports, and personal writing assignments like self-evaluations and learning diaries.

"Product" refers to that software system or service (including the source code) and the immaterial rights therein, which the Group has created in the Project.

"License" defines the rights to use, copy, redistribute, or modify the Product created by the Group in the Project.

"Deliverables" refers to both the Learning Assignments and the Product.

A.3 Rights to Deliverables

Immaterial rights of the Product belong to the students of the Group who have created the Product. Members of the Group hereby agree that they will attach the License to the Product before the Project completion, which is the date of *the final Project presentations in the Study Module*. The choice of the License will be documented and signed by all the members of the Group (see Appendix) and attached to the Deliverables, which as a whole must be delivered to the University for archiving purposes by the Group to finish the Study Module. If a student stops the Project prematurely, the rest of the Group can use such student's Deliverables to continue and finish the Project and to agree on the License, after the student who has quit has been heard.

The University can use the Deliverables in teaching and education research as follows: The research is conducted by the course teacher Ville Isomöttönen and his research colleagues, for example Tommi Kärkkäinen, and concerns project-based learning and its components such as group dynamics and software process in creative work. The research results and the development of teaching activities will be made in such a way that an individual student is anonymized. The research materials will be kept in a locked storage and the results are published in education research forums.

The students themselves decide whether they want their names to be attached to the Project presentation material that is placed on the University's website by the end of the Study Module.

This Agreement does not contain any obligations for compensation.

A.4 Signatures

Signatures of each student and Dean of the Faculty here.

Agreement Appendix

Example 1: Group places the Product under MIT-license.
Example 2: All members of the Group can use the Product as they wish.
(students' signatures)

References

1. Abdelkafi, N.: Towards open school: How to organize innovation contests with students. In: Heiß, H.U., Pepper, P., Schlingloff, B.H., Schneider, J. (eds.) Proceedings of Informatik. Lecture Notes in Informatics, vol. P-192, pp. 4–10. GI, Bonn (2011)
2. Alexander, D., Beyerlein, S., Metlen, S.: Processes to formalize sponsored educational activity agreements between industry and universities related to capstone design projects. In: Capstone Design Conference. Columbus, Ohio (2014)
3. Auer, S., Bryl, V., Tramp, S. (eds.): Linked Open Data – Creating Knowledge out of Interlinked Data: Results of the LOD2 Project. LNCS, vol. 8661. Springer, Heidelberg (2014)

4. Bach, L., Cohendet, P., Pénin, J., Simon, L.: IPR and "open creativity": The cases of videogames and of the music industry. In: DIME – The Creative Industries and Intellectual Property. London Conference (2008)
5. Bhaskar, R.: A Realist Theory of Science, 2nd edn. Harvester Press, Brighton, Sussex (1978)
6. Brown, R.: Dynamics within and between Groups. Basil Blackwell, Oxford, UK (1988)
7. Burge, J., Gannod, G.: Dimensions for categorizing capstone projects. In: Proceedings of 22nd Conference on Software Engineering Education and Training, pp. 166–173. IEEE Computer Society, Los Alamitos, CA (2009)
8. Burnell, L.J., Priest, J.W., Durrett, J.R.: Assessment of a resource limited process for multidisciplinary projects. SIGCSE Bull. **35**(4), 68–71 (2003)
9. Castanier, E., Coletta, R., Valduriez, P., Frisch, C.: Websmatch: A tool for open data. In: Proceedings of the 2Nd International Workshop on Open Data WOD 2013, pp. 10:1–10:2. ACM, New York (2013)
10. Chesbrough, H.W. (ed.): Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, MA (2003)
11. Clear, T., Goldweber, M., Young, F.H., Leidig, P.M., Scott, K.: Resources for instructors of capstone courses in computing. In: ITiCSE-WGR 2001: Working Group Reports From ITiCSE on Innovation and Technology in Computer Science Education, pp. 93–113. ACM, New York (2001)
12. Conradie, P., Mulder, I., Choenni, S.: Rotterdam open data: exploring the release of public sector information through co-creation. In: , 18th International ICE Conference on Engineering, Technology and Innovation (ICE), pp. 1–10 (June 2012)
13. Dahlander, L., Gann, D.M.: How open is innovation? Res. Policy **39**(6), 699–709 (2010)
14. Daniels, M., Berglund, A., Pears, A., Fincher, S.: Five myths of assessment. In: Proceedings of the Sixth Conference on Australasian Computing Education, ACE 2004, vol. 30, pp. 57–61. Australian Computer Society, Darlinghurst, Australia (2004)
15. Doepker, P.E.: Enhancing the product realization process by emphasizing innovation and entrepreneurship. J. Eng. Entrepreneurship **1**(1), 20–34 (2010)
16. Domingo, A., Bellalta, B., Palacin, M., Oliver, M., Almirall, E.: Public open sensor data: Revolutionizing smart cities. IEEE Technol. Soc. Mag. **32**(4), 50–56 (2013). winter
17. Eteläaho, A.: Analysis of the received applications in the open data contests in Finland 2010–2013 (draft.). Technical report Tampere University of Technology, Department of Pori (July 2014)
18. Fila, N., Myers, W., Purzer, S.: Work in progress: How engineering students define innovation. In: Frontiers in Education Conference (FIE). pp. 1–6. IEEE (2012)
19. Fincher, S., Petre, M., Clark, M. (eds.): Computer Science Project Work: Principles and Pragmatics. Springer-Verlag, London (2001)
20. Friberger, M.G., Togelius, J.: Generating game content from open data. In: Proceedings of the International Conference on the Foundations of Digital Games FDG 2012, pp. 290–291. ACM, New York (2012)
21. Fuller, U., Little, J.C., Keim, B., Riedesel, C., Fitch, D., White, S.: Perspectives on developing and assessing professional values in computing. ACM SIGCSE Bull. **41**(4), 174–194 (2010)
22. Goldberg, J.: Intellectual property and confidentiality issues in senior design courses. IEEE Eng. Med. Biol. Mag. **23**(6), 16–18 (2004)

23. Han, J., Kamber, M., Pei, J.: Data Mining: Concepts and Techniques, 3rd edn. Morgan Kaufmann Publishers, San Francisco (2011)
24. Hand, D.J.: Data, not dogma: big data, open data, and the opportunities ahead. In: Tucker, A., Höppner, F., Siebes, A., Swift, S. (eds.) IDA 2013. LNCS, vol. 8207, pp. 1–12. Springer, Heidelberg (2013)
25. Heikkinen, J., Isomöttönen, V.: Learning mechanisms in multidisciplinary teamwork with real customers and open-ended problems. Eur. J. Eng. Educ. 1–18 (2015, ahead-of-print). doi:10.1080/03043797.2014.1001818
26. Henson, K.L.: Student projects as a funding source. J. Inf. Syst. Educ. **21**(3), 291–298 (2010)
27. Huizingh, E.K.: Open innovation: State of the art and future perspectives. Technovation **31**(1), 2–9 (2011). Open Innovation - ISPIM Selected Papers
28. Isomöttönen, V.: Theorizing a one-semester real customer student software project course. In: Jyväskylä Studies in Computing, vol. 140, University of Jyväskylä Ph.D Thesis (2011)
29. Isomöttönen, V.: Making group processes explicit to student: a case of justice. In: Proceedings of the 2014 Conference on Innovation and Technology in Computer Science Education ITiCSE 2014, pp. 195–200. ACM, New York (2014)
30. Isomöttönen, V., Kärkkäinen, T.: The value of a real customer in a capstone project. In: Proceedings of 21st Conference on Software Engineering Education and Training, pp. 85–92. IEEE Computer Society, Los Alamitos, CA (2008)
31. Isomöttönen, T.: Open resources as the educational basis for a bachelor-level project-based course. In: Proceedings of the 7th International Conference on Computer Supported Education, pp. 46–56 (2015)
32. Jaakkola, H., Mäkinen, T., Henno, J., Mäkelä, J.: Open^n. In: 37th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), pp. 608–615. IEEE (2014)
33. Jaakkola, H., Mäkinen, T., Eteläaho, A.: Open data: Opportunities and challenges. In: Proceedings of the 15th International Conference on Computer Systems and Technologies CompSysTech 2014, pp. 25–39. ACM, New York (2014)
34. Kiilamo, T., Hammouda, I., Kairamo, V., Räisänen, P., Saarinen, J.P.: Open source, open innovation and intellectual property rights - a lightning talk. In: Hammouda, I., Lundell, B., Mikkonen, T., Scacchi, W. (eds.) OSS 2012. IFIP(AICT), vol. 378, pp. 298–303. Springer, Heidelberg (2012)
35. Kiili, k, Kiili, C., Ott, M., Jönkkäri, T.: Towards creative pedagogy: Empowering students to develop games. In: Felicia, P. (ed.) 6th European Conference on Games Based Learning, pp. 250–257. Academic Conferences Limited, Reading, UK (2012)
36. Kilpatrick, W.: The project method. Teachers Coll. Rec. **19**(4), 319–335 (1918)
37. Klug, B.: To grade, or not to grade: a dramatic discussion in eleven parts. Stud. High. Educ. **1**(2), 197–207 (1976)
38. Leidig, P.M., Lange, D.K.: Lessons learned from a decade of using community-based non-profit organizations in information systems capstone projects. In: Proceedings of the Information Systems Educators Conference, vol. 1435 (2012)
39. Moore, R.: For knowledge: tradition, progressivism and progress in education–reconstructing the curriculum debate. Camb. J. Educ. **30**(1), 17–36 (2000)
40. Preciado, J.C., Morales-Chaparro, R., Sánchez-Figueroa, F.: Engineering open data visualizations over the web. In: Luo, Y. (ed.) CDVE 2014. LNCS, vol. 8683, pp. 51–59. Springer, Heidelberg (2014)
41. Otjacques, B., Stefas, M., Cornil, M., Feltz, F.: Open data visualization: keeping traces of the exploration process. In: Proceedings of the First International Workshop on Open Data WOD 2012, pp. 53–60. ACM, New York (2012)

42. Pears, A., Daniels, M.: Developing global teamwork skills: The Runestone project. In: Education Engineering (EDUCON), pp. 1051–1056. IEEE (2010)
43. Pikkarainen, M., Codenie, W., Boucart, N., Alvaro, J.A.H. (eds.): The Art of Software Innovation - Eight Practice Areas to Inspire your Business. Springer, Berlin Heidelberg (2011)
44. Shaw, M., Tomayko, J.E.: Models for undergraduate project courses in software engineering. In: Tomayko, J.E. (ed.) SEI 1991. LNCS, vol. 536, pp. 33–71. Springer, Heidelberg (1991)
45. Silvernagel, C., Schultz, R.R., Moser, S.B., Aune, M.: Student-generated intellectual property: perceptions of ownership by faculty and students. J. Entrepreneurship Educ. **12**, 13–33 (2009)
46. Stearns, D., Dalbey, J., Turner, C., Kearns, T.: Report: A capstone project involving a hundred students, for an industrial partner. In: Proceedings of the International Conference on Engineering Education, 21–25, July Valencia, Spain. INEER (2003)
47. Suri, D.: Providing "real-world" software engineering experience in an academic setting. In: 37th Annual ASEE/IEEE Frontiers in Education Conference, pp. S4E–15-S4E-20. IEEE (2007)
48. Telikicherla, K.C., Choppella, V.: Enabling the development of safer mashups for open data. In: Proceedings of the 1st International Workshop on Inclusive Web Programming - Programming on the Web with Open Data for Societal Applications IWP 2014, pp. 8–15. ACM, New York (2014)
49. Tomayko, J.E.: Forging a discipline: an outline history of software engineering education. Autom. Softw. Eng. **6**(1), 3–18 (1998)
50. Tuunanen, T., Koskinen, J., Kärkkäinen, T.: Automated software license analysis. Autom. Softw. Eng. **16**(3–4), 455–490 (2009)
51. Vallino, J.: Ownership of artifacts and intellectual property for software-intensive capstone design projects. In: Capstone Design Conference. Columbus, Ohio (2014)
52. Vanhanen, J., Lehtinen, T.O., Lassenius, C.: Teaching real-world software engineering through a capstone project course with industrial customers. In: Proceedings of the First International Workshop on Software Engineering Education Based on Real-World Experiences, pp. 29–32. IEEE (2012)
53. Vincent, C., Wild, P.: Current practices in final year engineering design courses. In: Proceedings of the Canadian Engineering Education Association (2011). http://library.queensu.ca/ojs/index.php/PCEEA/article/viewFile/3809/3769
54. Warnick, G.M., Todd, R.H.: Importance of providing intellectual property to sponsoring companies when recruiting capstone projects. Int. J. Eng. Educ. **27**(6), 1238 (2011)
55. Werner, L., Kuenning, G., Sebern, M., Vallino, J., Wong, W.E.: Software engineering education via the use of corporate-sponsored projects: a panel discussion of the approaches, benefits, and challenges for industry-academic collaboration. In: IEEE 26th Conference on Software Engineering Education and Training (CSEE&T), pp. 346–350. IEEE (2013)
56. Yang, H.L., Cheng, H.H.: Creativity of student information system projects: from the perspective of network embeddedness. Comput. Educ. **54**(1), 209–221 (2010)
57. Yunfei, P., Qin, D.: Cultivating the innovation ability of college students in course teaching. In: First International Workshop on Education Technology and Computer Science. ETCS 2009, vol. 1, pp. 828–831. IEEE (2009)

Continuous Assessment in the Evolution of a CS1 Course: The Pass Rate/Workload Ratio

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Abstract. The first programming course (Programming-1, CS1) in the Informatics Engineering Degree of the Facultat d'Informàtica de Barcelona was completely redesigned in 2006 in order to reinforce the learn-by-doing methodology. Along the following eight years several pedagogical measures —mostly related with continous assessment— were introduced with the aim of increasing the pass rate of the course without lowering its high quality standards. This paper analyzes to what extent the added workload on faculty entailed by these measures affects the pass rate. We use a classical marginal cost-benefit approach —from Economics— to compare these two values along time. This process allows us to relate the evolution of the pass rate of students with the workload of the faculty through a productivity curve, as well as to assess the impact of each pedagogical measure. We conclude that, for this course, continuous assessment is expensive. In fact, abstracting from short term oscillations, the slope of the productivity curve is close to zero.

Keywords: CS1 · Marginal cost-benefit analysis · Continuous assessment

1 Introduction

The Programming-1 course (CS1) is the first course on programming taught in the Informatics Engineering degree at the Facultat d'Informàtica de Barcelona (FIB) of the Universitat Politècnica de Catalunya (UPC). It receives around 450 new students per academic year, and it requires about 15–20 faculty members and two coordinators. In September 2006, the course was completely redesigned adopting a "learn-by-doing" approach [1] that has been applied until now. The working basis is a strategically selected and carefully organized collection of programming exercises that must be solved using the C++ programming language. An integral part of the course is an online *programming judge* [8] that

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automatically verifies in real time whether a program proposed by a student is a correct solution for a programming exercise. Such a tool is a very useful platform for supporting a programming course, since it is 24-hours available to the students and provides them with a large complementary training source for the self-organization of their own learning process. However, the first two years with the experience of using the programming judge showed that a high number of students failed to pass the course anyway [3]. According to the data collected in the online judge, most students invested far less time in the course than its required workload of the course (7.5 ECTS[1]).

As lecturers in a Technical University, we are deeply engaged in the development of a learning society. However, there is a big gap between general theories [1,10,11] and our everyday lecturing task. Concerned and committed to the challenge of helping students to achieve the theoretical and practical knowledge required to attain a passing mark, the CS1 academic staff has introduced a series of measures with the aim of motivating the students to work harder, more autonomously and more continuously, while maintaining the general goals, level and approach of the course. As a consequence, the course has suffered several amendments along time, which account for an important increase of continuous assessment for students at the expense of a simultaneous increase of the workload for the faculty members.

Since the time devoted to teaching is a limited (and even public, in our case) resource, it should be optimized with no detriment of its quality. To do so, it is fundamental to estimate the cost–benefit of the different faculty tasks involved in the course. Such information is definitely helpful for the assessment of the undertaken measures in terms of their productivity (or effectiveness). This paper is a proposal in this direction and it aims at providing a starting point for fruitful discussions and considerations.

The analysis of the temporal evolution of the evaluative activities of a course is a well established subject [7]. Following a long tradition in education analysis [2,4], we use the rate of students passing the course as our primary measure of production. Specifically, we perform a cost–benefit analysis that determines the impact of the measures introduced in the last years in the CS1 course by contrasting the pass rate of the students with the workload of the instructors. We propose a simple way to interpret them under economic terms by means of *productivity* and *marginal gain* notions [13]. For that aim, we use the following basic magnitudes:

- N_t denotes the total number of students at time t,
- P_t denotes the number of students passing the course at time t, therefore
- $100P_t/N_t$ corresponds to the *pass rate* at time t and,
- W_t denotes the *workload* (as the number of working hours) that faculty members are required to invest on the course at time t.

[1] European Credit Transfer and Accumulation System (ECTS) is a standard for comparing the study attainment of higher education across the European Union. One ECTS credit corresponds to 25h of student work.

It is clear that our model and our data are limited and do not take into account several pedagogical, psychological and sociological aspects that affect the behavior of both students and faculty members. Nevertheless, we think that it can provide insights in the way this massive course has evolved as well as tools for future directions. According to the results reported here, we can provide some criteria to assess the benefit of each of the introduced measures. We observe that the benefit of incrementing the load of continuous assessment reaches soon a limit, regarding the pass rate of the students and the workload of the instructors.

The forthcoming sections are organized as follows. First, in Sect. 2, we give an overview of the context in which the CS1 course is placed and we describe the original design of the course as in 2006. In Sect. 3, we detail the different measures on the evaluative activities proposed from 2006 until now. The impact of those measures in the pass rate of the students is analyzed in Sect. 4. Later, the total workload induced by the CS1 course is described and estimated in Sect. 5. Section 6 presents the cost-benefit and the marginal analysis method that will be used in Sect. 7 to carry out an analysis of the relation between pass rate and workload by means of economics concepts. Finally, Sect. 8 closes the article by presenting our concluding remarks.

2 Context and Design

It is usual around the world that, after concluding their secondary studies, students do some kind of multi-subject general exam in order to be able to apply for a vacancy at a University. In the Spanish educational system, those exams are valid countrywide and the later admission to Universities (in terms of number of vacancies, minimum grades, etc.) is established by an independent governmental office. Thus, except for a few very specific areas like art and sport, new incoming students are not previously filtered by any specific admission exam designed by the Universities where they end up studying. In order to compensate that lack of specific filtering, the first year in most of the undergraduate degrees becomes somehow a selective procedure. That is also the case for the FIB, where new students must succeed in (at least) the four subjects composing the first year of the degree in (at most) two years. Table 1 shows the percentage of students passing the first four semesters at their first try (i.e. in one year) at FIB in the academic year 2006–2007. We do not enter in the debate of what is an acceptable pass rate. However, the general impression was that the percentage for CS1 was too low and it should be improved.

By 2006, there was also a general consensus on the fact that most students of CS1 did not master fluently enough the programming skills needed for subsequent courses. Consequently, the course was completely redesigned in September 2006. This was done under the agreement that the level of required programming skills should be better designed and that its contents should not suffer changes in the forthcoming years. In the following subsection we give a short overview of the course (full details can be found in [3]).

The FIB offers CS1 twice a year, every academic year: once at the fall semester and once at the spring semester:

- The **Fall term** spans from September to February. It is during this term that new students arrive every year. For most of them, CS1 is the first serious attempt to learn to program. During this semester, the lecturers of CS1 put a special effort in motivating those new students for properly facing the Informatics Engineering degree.
- The **Spring term** spans from February to July. Virtually all students in this term are those who failed in the previous semester(s). Since they come from a negative experience, some students do not have a positive and constructive attitude in this second attempt. Contradictorily, the fact of having now some knowledge about the subject motivates a high level of absenteeism in the classes. In general, the students in this semester are harder to motivate.

Table 1. Passing rate of each subject composing the first year in the Informatics Engineering degree in the academic year 2006–2007: %Enr is the percentage of students who pass over all the students enrolled; and %Exa is the percentage of students who pass over all who took the final exam.

Subject	%Enr	%Exa
Algebra	24	32
Computers-1	44	57
Physics	39	48
Programming-1	20	32

In spite of the different nature of the students in each semester, the organization of the course does not change, nor its evaluation. Only the contents of the lessons (specially the practical ones) may be adapted according to the audience. In 2006, the course had 3h of theory lectures and 3h of practical lessons per week. In both semesters, the students were organized into groups: of 60–80 people for theory sessions, and of 15–20 people for practical classes. The theory sessions are, as expected, the place to introduce the concepts, techniques and tools required to acquire the necessary knowledge and to tackle the contents of the practical classes.

The main goal of CS1 was always to ensure that students learn and master basic programming skills. By 2006, there was the will to face that goal with a reinforcement of the practical side of the subject. Thus the course was organized around the notion of "programming problems", i.e., small programming exercises described with a clear statement in terms of valid inputs and desired outputs. The students must write a small, correct and efficient C++ program that solves the problem stated in the exercise and behaves as expected. During the course, students should solve as many programming problems as possible among the offered collection, which contains more than 300 problems.

The collection of programming exercises was conveniently designed and organized by topic and difficulty. Some of those problems were expected to be solved individually during the practical sessions with the help of an instructor.

Some other problems were expected to be solved by the students on their own, without the instructor's immediate support and out of the regular lessons' time. During the exams, students were asked to solve programming problems with a difficulty similar to those in the course collection. Those exams took place in a laboratory room similar to the one where students used to work every week.

In order to apply this learn-by-doing methodology, an educational online programming judge was developed [8]. Online programming judges are web systems that store a repository of problems with the facility to check whether a candidate solution is correct. The judge executes the submitted program on a set of public and private test cases, and matches the obtained outputs with the expected ones. Online judges originated in programming contests such as the UVa Online Judge [9], and have widely been adapted to educative settings [6,12,14]. In particular, the judge of CS1 has evolved into jutge.org, an open access virtual learning environment for computer programming [8] which is nowadays used for further programming courses in the Informatics Engineering degree and other degrees at UPC, as well as for training student teams for international programming competitions.

For every programming exercise in the judge, there is a clear statement with a description of the problem to solve. The statement includes a set of sample inputs and specifies the corresponding correct outputs. Once programmed, the student is expected to compile his program until a running code is produced. Then, the program should be tested for different inputs, those in the statement at first. The student must think, however, about other possible inputs not in that sample set. All these steps are performed in a raw environment since only a text editor and a C++ compiler is needed. Once the program is considered to be tested enough, the student submits it to the judge for its evaluation. At that point, the judge compiles the program again and tests it not only for the sample input set of the statement, but also for a private input set. After a few seconds the judge will come out with a verdict: a *green* light (green verdict) if the program is correct and passes all the input sets, and a *red* light (red verdict) if the program fails in some case (see Fig. 1). In this later case, a clue is feedbacked to the student to help her finding the mistake. Other verdicts are possible for describing other situations.

The use of the programming judge was an inflection point for our programming courses. Indeed, this kind of *public good* offers clear advantages to the

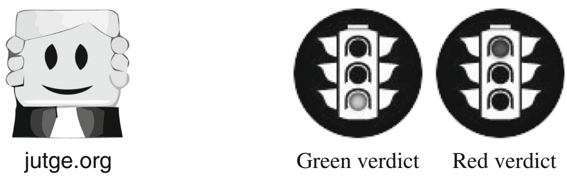

Fig. 1. jutge.org with two of its verdict icons: the green light icon for submissions that pass all the test cases of a problem, and the red light icon marking submissions that fail some test cases.

students since it provides them with a huge source of exercises, gives them freedom at work and it may be used 24/7. It is also a valuable tool for instructors because it dynamizes the practical sessions and it allows to track the work and evolution of the students, as well as facilitating the organization and management of the exams.

The judge started to be used also for the exams, where it was compulsory to submit a correct solution in order to be evaluated. After the exam, the teachers only evaluated those programs with green verdict, mainly to grade their adequacy to general quality criteria. The aim of this strict rule was to make the students used to practice on their own, and to reinforce the goal of getting programs that run and not only algorithms on a paper. However, the students at that moment perceived it as an unfair method.

3 Evolution

The immediate results after introducing the methodology mentioned above were not as successful as expected. As a consequence, several measures were taken in the forthcoming editions with the intention of improving the situation. We now describe those measures and comment on how they have affected the evolution of the course. Unfortunately, we will see later that none of those measures was able to boost the pass rate on its own. We divide the total analysis time into eight periods $t_0, \ldots, t_8$, and sometimes refer to them as *timestamps*.

- t_0 **Kick-off (2006–2007):** The first edition of this course had two exams (a mid-term exam and a final exam) consisting of two practical problems each. The exams took place at the same rooms where students were used to work every week in their practical lessons. The students were asked to solve the problems, to implement their solutions and to submit their programs using the online judge. Each solution to a problem could be submitted more than once. Only those programs that obtained a green verdict were then graded by the instructors. All the other programs with a red verdict were given the lowest mark, i.e., a zero in the Spanish system.
- t_1 **Introduction of Quizzes (2007–2008):** In order to encourage students to work in a more continued way, four additional practical exams were introduced along the semester. Those exams consisted of an exercise of the same format and complexity as those solved in the practical sessions, and thus generally simpler than the problems included in the mid-term and final exams. The goal of this amendment was two-fold: first, to help students to get used to work under the same scenario where the mid-term and final exams take place, and second, to encourage them to work hard and in a continuous way. They could obtain up to a 10% of the final qualification by succeeding in those exams. Still only green verdicts were graded by lecturers.
- t_2 **Grading Red Verdicts (2008–2009):** Some lecturers, and most of the students, considered that grading only those programs that obtained a green verdict was somehow unfair. Therefore, the FIB urged the coordinators of the course to remove this restriction and force them to grade all the solutions manually, independently of its final verdict.

t_3 **Hand-written Final Exam (2009–2010):** The fact of only having computer-based exams was a significant novelty for students, because they were rather used to write down their exams on paper. Somehow, the feeling that computer-based exams were the reason for the bad results grew up among students. In order to neutralize that opinion and minimize the effects of that situation, the final exam changed back to a traditional hand-written format.

t_4 **New Degree (2010–2011):** In September 2010, the FIB introduced a new curriculum for the Informatics Engineering degree to comply with the new European Union regulations on graduate studies. This new curriculum is the one that the CS1 course still follows nowadays. Two most relevant changes were introduced: (a) theory lectures were reduced from 3 to 2h per week, and (b) the continuous assessment increased in quantity and importance, by considering practical exercises as mid-term exams with a greater weight in the final mark than they had before.

t_5 **Lists of Problems to Hand-in (2011–2012):** In order to comply with the required increase of continuous assessment, lists of mandatory practical exercises for each topic of the course were introduced. Those lists were exclusively composed by exercises in the course collection of the online judge. Therefore, the students could work on them during their practical sessions and had the possibility to solve them before the exams. The exercises of the mid-term exams were taken from those lists. In order to have the right to participate in a mid-term exam, the students were required to achieve a green verdict in the online judge for at least 70% of the exercises of the corresponding lists.

t_6 **Re-evaluation Course (2012–2013):** As another effort to increase the pass rate, the FIB introduced a second-chance exam for students who did not succeed the course, but whose final grade was close to the passing threshold mark (i.e., a five in the Spanish grading system). That re-evaluation course is a summarized 12-hour course that takes place once the usual course is finished. Attendance to the lectures is mandatory. As in the normal course, the right to get the remedial final exam is also conditioned to solving 70% of the problems of the proposed lists. If a student does not pass the exam, he keeps the original final qualification of the course. Otherwise, he gets a 5 as final mark and thus passes the course with the minimal qualification. No higher marks can be obtained.

t_7 **Mid-term Exams with New Exercises (2013–2014):** In order to lead the students towards a more creative and responsive learning process, the mid-term tests changed their composition to completely new problems that were unknown to the students by the time of the exam.

t_8 **Course Diversification (2014–2015):** From 2006 to 2014, the collection of training exercises for CS1 in the online judge remained almost unchanged and only the evaluation of the course varied. Trying to further reinforce a creative learning, we devote an effort to set-up a diversified content for the course. Such a diversification might reinforce the idea of enrolling always in a novel course. Further, it might motivate the students (specially, those repeating the course) to face the semester willingly.

4 Pass Rate

Taking into account the evolution of the course, as detailed in the previous section, we now turn our attention into the evolution of the pass rate as a function of the measures taken over time. For every timestamp, Table 2 shows the number of enrolled students and the number of students that pass the course, for every semester and academic year since 2006. From that information, Fig. 2 plots the pass rates. One can see that the proportion of students who succeed the course at a first attempt started at around 20% and is now slightly over 45%. Some additional observations can be done:

- The introduction of quizzes at t_1 had almost no effect in the percentage of students who finished the course successfully.
- Grading red verdicts at t_2 may have removed the feeling of suffering an unfair evaluation, but it had almost no effect on increasing the pass rate.
- The introduction of a written final exam at t_3 modestly improved the percentage of students who succeeded by a 3%.
- The adaptation to the new degree at t_4 seems to had some modest effect, since the percentage of the pass rate boosted to a successful 30%.
- Using lists of problems to hand-in for the quizzes at t_5 turned the percentage of students passing the course up to 41%. In spite of that positive result, the instructors were not completely pleased with this action since they got the impression that it motivated memorizing programs rather than learning to design and implement them. The students concentrated too much in the problems of the lists and did not use the other problems to work more and progressively. Without that background, they got often blocked and frustrated when tackling different or more difficult problems.
- The remedial exam introduced at t_6 increased the pass rate from 41% to almost 50%. This amendment seems to suggest that there is a significant percentage

Table 2. For every timestamp t, number of enrolled students (N_t), number of students who pass the course (P_t) and its percentage (%), per semester and academic year.

	Fall			Spring			Year		
Timestamp	N_t	P_t	%	N_t	P_t	%	N_t	P_t	%
t_0-Kick-off	377	77	20	344	67	19	377	144	38
t_1-Introduction of quizzes	492	102	21	395	132	33	492	234	48
t_2-Grading red verdicts	497	105	21	380	136	36	497	241	49
t_3-Hand-written final exam	417	98	23	360	118	33	417	216	52
t_4-New degree	493	145	29	296	92	31	493	237	48
t_5-Lists of problems to hand-in	492	205	42	220	69	31	492	274	56
t_6-Re-evaluation course	465	232	49	181	83	46	465	315	68
t_7-Mid-term exams with new exercises	436	166	38	205	96	47	436	262	60
t_8-Course diversification	448	209	46	169	90	53	448	299	67

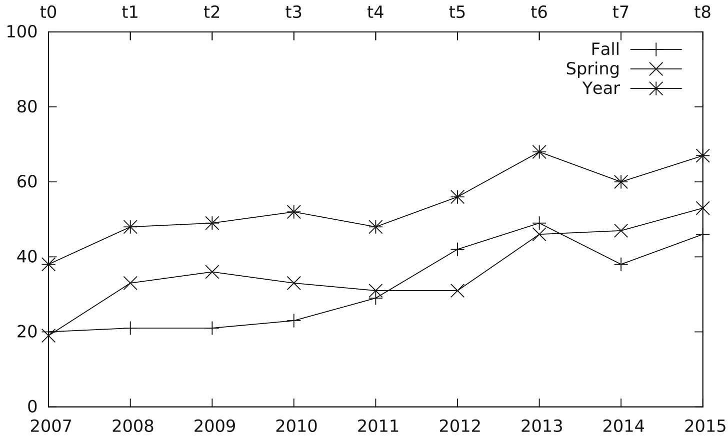

Fig. 2. Percentage of students who pass the course by year (or timestamp): a graphical representation of the 4th, 7th and 10th columns of Table 2. Timestamp t_0 is labeled as 2007 but the data corresponds to the course 2006–2007, and so applies to the rest of timestamps, respectively.

of students close to the passing mark threshold who, with a bit more practice and personalized attention, succeed to pass the CS1 course. The mandatory attendance to lectures may have some influence on that success.

– Introducing new problems in the exams that were not in the course lists at t_7 decreased the pass rate from 50% to 38%. This important decrement reinforces the risks mentioned for the initiatives taken at t_5. The impression of the faculty members is that this decrement may be temporal and should improve in the forthcoming semesters.
– With the course diversification done at t_8, the pass rate grew up from 38% to 46%. It seems that tackling new training exercises motivates the students to work harder. This seems to help them to face the exams with a more positive attitude. We observed also a positive effect in the acquisition of programming skills.

Observe, that the pass-rate curves for the fall semester and the academic year follow similar tendencies. The pass rate of the spring semester is in general higher that the one for the fall semester. Only in t_5 and t_6 the rate drops below. However, as it can be seen in Fig. 2 the pass rate in the spring semester shows a different tendency.

5 Workload

Our goal in this section is to describe the method used to estimate the workload of the course in each of its timestamped stages, measured as the total number of working hours invested by faculty members. We denote the workload as W_t, where $t \in \{t_0, \ldots, t_8\}$. Computing W_t is difficult because every new edition of the course involves slightly different tasks, faculty members with different profiles, different dedication times and different personal efficiencies. Moreover, the faculty members involved in the course also changes from semester to semester. Also the perception about the time invested in each task is different for each faculty member. In order to capture the different type of tasks included in W_t, we have approximated W_t by decomposing it into the following measures:

- E_t: time to design, to test and to prepare exams,
- T_t: time to prepare a theory session,
- L_t: time to supervise practical sessions,
- G_t: time to mark exams,
- V_t: time to supervise exams,
- C_t: time to coordinate the course,
- R_t: time to redesign the course, and
- S_t: time to maintain the software.

Therefore, for each timestamp t, W_t is conformed by the number of working hours required by the sum of all these tasks, i.e.,

$$W_t = E_t + T_t + L_t + G_t + V_t + C_t + R_t + S_t.$$

To a greater or smaller extend, these quantities are dependent on the number of students taking the course. Observe that we do not include here the working hours required for the initial design of the course and of the design and implementation of the online judge.

In order to estimate W_t, in the fall semester of the course 2014–2015 we conducted a survey among the faculty members who were involved in teaching CS1 since 2006. They were asked to provide us with an estimation of the hours they invest in each of the tasks. The values used for the estimations are the averages over the answers received to that survey. Since we did not have similar information from previous editions of the course, and since many of the teachers who participated in the survey taught CS1 in several editions of the course, we extrapolated the results to past editions taking into account the way in which each applied amendment impacted the workload of each task. The technicalities for the calculation of the values of each task are given as Appendix A. The obtained values are shown in Table 3.

Figure 3 shows the evolution over time of the workload of each of the tasks in the fall semester. One can see that the most significant contributions to W_t at each timestamp are practical lectures and theory lectures. In spite of that, the faculty members have the impression that the same does not apply to students. Some students, as the course advances, show a tendency towards not attending lectures.

One can also see that most of the tasks (except G_t and V_t, i.e., marking and supervising exams) are almost constant over time. Both measures increase in time and are the principal reason why W_t also increases. Indeed, this behavior is as expected because the measures introduced along the years are mostly evaluative ones, i.e., directly or indirectly in the form of exams. Therefore, it is

Table 3. Workload (in hours) of the tasks of the course per semester.

	Fall								Spring							
	E_t	T_t	L_t	G_t	C_t	R_t	S_t	V_t	E_t	T_t	L_t	G_t	C_t	R_t	S_t	V_t
t_0	24	707	1696	100	33	0	300	75	24	483	1548	91	32	0	300	68
t_1	36	922	2214	196	39	0	300	98	36	555	1777	158	34	0	300	79
t_2	36	931	2236	596	39	0	300	99	36	534	1710	456	34	0	300	76
t_3	30	781	1876	500	35	0	300	72	30	506	1620	432	33	0	300	63
t_4	30	616	2218	591	49	45	300	382	30	277	1332	355	39	45	300	229
t_5	18	615	2214	590	49	10	300	381	18	206	990	264	35	10	300	170
t_6	25	611	2142	573	49	16	300	363	22	184	839	225	35	16	300	143
t_7	37	575	2012	538	48	0	300	340	31	207	947	254	36	0	300	161
t_8	37	590	2066	552	48	358	300	350	31	173	785	210	34	149	300	133

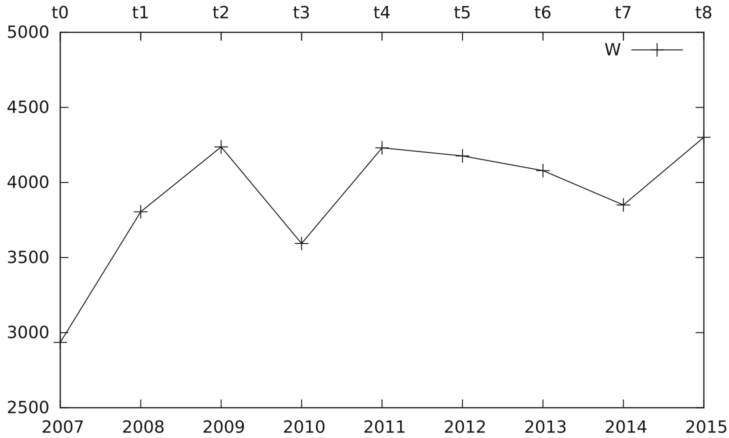

Fig. 3. Workload (in hours) of the course by year (or timestamp) at the fall semesters (i.e., aggregates of Table 3).

natural that they mostly impact the tasks involved in designing, supervising and assessing exams.

Once we have an estimation of W_t, we can calculate the faculty workload per student at timestamp t as

$$W_t^s = W_t/N_t.$$

This measure approximates how many of the working hours of the faculty members are dedicated to each student. In other words, it estimates what is the *cost* of every student in terms of faculty working hours. Table 4 contains the data for both semesters and the sum over the year, and Fig. 4 shows the evolution of this cost over time for the fall semester. As the plot shows, the cost per student increased by an hour from t_0 to t_7, and nearly by one more hour from t_7 to

Table 4. Total and per student workload (in hours) of the tasks of the course per semester and year.

	Fall		Spring		Year	
Timestamp	W_t	W_t/N_t	W_t	W_t/N_t	W_t	W_t/N_t
t_0-Kick-off	2937	7.79	2548	7.41	5485	14.55
t_1-Int. of quizzes	3807	7.74	2940	7.44	6748	13.72
t_2-Grad. red verdicts	4240	8.53	3146	8.28	7386	14.86
t_3-Hand-written final ex.	3597	8.63	2984	8.29	6581	15.78
t_4-New degree	4232	8.59	2608	8.81	6840	13.88
t_5-Prob. to hand-in	4177	8.49	1994	9.06	6172	12.54
t_6-Re-evaluation	4080	8.78	1766	9.76	5847	12.57
t_7-Exams with new problems	3851	8.83	1938	9.46	5789	13.28
t_8-Diversification	4303	9.61	1818	10.76	6122	13.67

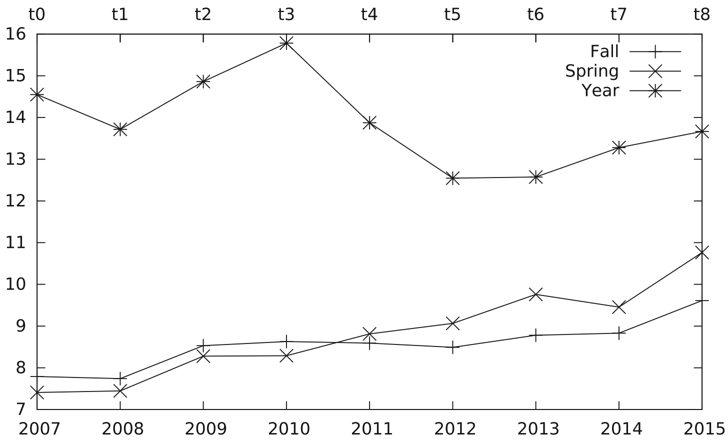

Fig. 4. Hours of faculty workload per student $W_t^s = W_t/N_t$ by year (or timestamp).

t_8. As we said before, these extra hours mostly corresponds to the increase in grading and supervising exams. Figure 4 shows that an important increment in the cost per student appears at t_2, together with the measure of grading also the programs that obtained a red verdict by the online judge. In spite of that effort, the t_2 amendment did not have much influence on the pass rate, as we saw before.

6 Method

In this section we go deeper into the analysis of the pass rate and the workload by relating them by means of economics concepts. We present the cost-benefit and the marginal analysis method that we will use for that aim.

On the surface, one can think that the whole evolution of the course (by means of the measures taken) is a great success since the total workload W_t incremented just by a modest 13% while duplicating the pass rate in the side of students. However, the measures taken did not affect the whole workload but only G_t and V_t, which became tripled. Therefore, the duplication of the pass rate does not seem to justify the triple increment of $G_t + V_t$.

In order to get more insight on how each measure affects the pass rate, in the following we conduct a cost-benefit analysis relating workload and pass rate. Economists define *productivity* or *effectiveness* as the ratio of outputs to inputs used in the production process [13]. In our case, being very coarse and with all the safeguards and warnings required, one can see that the number of students that succeed the course as the *output*, and the total workload as the *input*. Therefore we talk about the *course productivity* at timestamp t, Π_t, as the ratio of these two quantities over time, i.e.,

$$\Pi_t = P_t/W_t.$$

Recall that the S-curve shape in Economics [13] has generally the interpretation that once the inflection point is reached there is no sense to continue increasing the input (i.e., the workload of the course, in our case) because this increment has no impact on the output. In fact, it is negative. Figure 5 shows the behavior of Π_t from t_0 to t_8 for the fall and spring semester, as well as for the total academic year. Abstracting from short term oscillations, the tendency of the year productivity seems to approach the S-shape. This is also true in the fall semester. However, the irregular behaviour of the spring semester is reflected in its productivity curve, making it difficult to analyze its tendency. Recall that the students conforming the spring semester are those who failed in the previous semester(s) and that strongly conditions and bias the outcome. The results of the spring semesters can not be stand-alone analyzed, but inside the

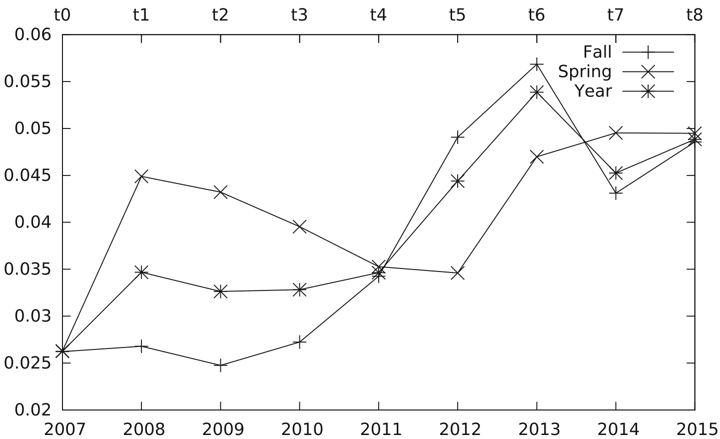

Fig. 5. Productivity Π_t by year (or timestamp).

academic year. Specifically, the year productivity curve Π_t for the fall semester and the academic year has four sections that are noteworthy (Fig. 5):

1. The first one is from t_1 to t_2 in which it decreases due —as we already mentioned— to the grading of exam problems labeled with a red verdict by the online judge.
2. The second one is from t_2 to t_6 where it increases. During this period we can read from the curve that the course was being *productive* in the sense that the amendments applied were being effective as was the increase of the workload.
3. The third period corresponds to t_6 to t_7 in which Π_t drastically decreases. In this period the workload increased but the number of students that passed the course decreased. This is because the mid-term practical exams are currently composed by new problems that are not known in advance by students.
4. From t_7 to t_8 the curve moderately increases again. Even if the workload has increased this seems to be compensated by the increase of the pass rate.

We consider now more closely the impact of the different measures over time. To capture the variation of work among periods we define, for $t \in \{t_1, \ldots, t_8\}$,

$$\Delta W_t = W_t/N_t - W_{t-1}/N_{t-1}$$

and for the variation of students that succeed on the course we define

$$\Delta P_t = P_t/N_t - P_{t-1}/N_{t-1}.$$

We compare both of them by the rate $\Delta_t = \Delta W_t/\Delta P_t$. Making again an abusing use of economics terminology, we call this rate the *marginal gain* at time t of the undertaken measure [13]. We can take into consideration the following five general cases:

(a) Case $\Delta W_t > 0$ and $\Delta P_t < 0$. Increasing the workload while decreasing the percentage of successful students corresponds to a very negative undertaken measure. It seems definitely a situation to avoid.
(b) Case $\Delta W_t < 0$ and $\Delta P_t < 0$ can be considered in general as a negative option. It may be desirable to decrease ΔW_t but not at the cost of decreasing also ΔP_t. However, if $|\Delta W_t| \gg |\Delta P_t|$ the undertaken measure deserves to be carefully analyzed. It might be the case that a small decrease in ΔP_t is justified if it implies a huge decrease of the workload.
(c) Case $\Delta W_t \geq 0$ and $\Delta P_t \geq 0$ and $\Delta W_t \gg \Delta P_t$. This corresponds to a big increase of work for a small increase in the number of passing students, which is in general a situation to avoid.
(d) Case $\Delta W_t \geq 0$ and $\Delta P_t \geq 0$ and $\Delta P_t \gg \Delta W_t$. This is a positive case, a small increase in the quantity of work produces a big improvement.
(e) Case $\Delta W_t < 0$ and $\Delta P_t > 0$. This is in general an outstanding measure. The larger the distance between ΔW_t and ΔP_t, the better the measure.

It is worth observing that the cases where Δ_t is really unbalanced deserve special attention. Such cases reflect an important disagreement between the effort (measured by ΔW_t) and the results (measured by ΔP_t).

7 Analysis

In this section we interpret the amendments taken in the CS1 course in terms of the cases described in the previous Section, using the cost-benefit and marginal analysis method. Table 5 shows the values of ΔP_t, ΔW_t and Δ_t over time. We comment on the results for the academic year and add some comments when there is a variation in some of the semesters.

Table 5. Variations on the pass rate, workload and marginal gain, per semester and year.

	Fall			Spring			Year		
	ΔP_t	ΔW_t	Δ_t	ΔP_t	ΔW_t	Δ_t	ΔP_t	ΔW_t	Δ_t
$t_0 - t_1$	0.31	−0.05	−0.17	13.94	0.04	0.00	9.36	−0.84	−0.09
$t_1 - t_2$	0.40	0.79	2.01	2.37	0.84	0.35	0.93	1.15	1.23
$t_2 - t_3$	2.37	0.10	0.04	−3.01	0.01	0.00	3.31	0.92	0.28
$t_3 - t_4$	5.91	−0.04	−0.01	−1.70	0.52	−0.31	−3.73	−1.91	0.51
$t_4 - t_5$	12.25	−0.09	−0.01	0.28	0.25	0.89	7.62	−1.33	−0.17
$t_5 - t_6$	8.23	0.28	0.03	14.49	0.69	0.05	12.05	0.03	0.00
$t_6 - t_7$	−11.82	0.06	0.00	0.97	−0.30	−0.31	−7.65	0.70	−0.09
$t_7 - t_8$	8.58	0.77	0.09	6.43	1.31	0.20	6,65	0.39	0.06

t_1 **Introduction of Quizzes (2007–2008):** This measure falls under Case (e). Since $|\Delta W_t|$ is very small this was a moderately productive measure. Observe also that for the spring semester this measure falls under Case (d) however again under Case (e) for the whole year.

t_2 **Grading Red Verdicts (2008–2009):** This amendment falls under Case (c). As we already mentioned this was a negative and unjustified measure that wastes a huge amount of resources. On one hand, it fails to take advantage of the online judge as a tool to help assessment, but on the other hand — and as a consequence— it requires working hours that could be probably invested in more productive activities. As before, the positiveness on the second semester, that falls under Case (d), cannot change the tendency of the first semester.

t_3 **Hand-written Final Exam (2009–2010):** The amendment falls under Case (d). So it seems to be a positive measure. Indeed, given that the red verdicts have to be assessed, it is better to have written exams since the time to design and supervise them is lesser. However, this is only true in the context of evaluating red verdicts, not in general. If compared against t_1 then it seems to be a negative measure.

t_4 **New Degree (2010–2011):** This is a positive measure that falls under Case (e) for the first semester. The measure can be classified under (a) for the spring semester and under (b) for the whole year. This is the only measure in which the spring semester changes the final tendency. Introducing mid-term exams with a significant weight over the final grade seems to have a positive impact on the pass rate. This compensates the decrease of hours in theory lectures.

t_5 **Lists of Problems to Hand-in (2011–2012):** This seems to be an outstanding amendment. It falls under Case (e). However one has to be prudent with such kind of amendments. There is no doubt that it increased the pass rate while decreasing the workload, but the contents of mid-term exams were previously known by students. At the end, that might be a drawback because of the indirect use of mechanical learning, which is a risky practice. As C. P. Snow strongly stated:

> *"It was an examination in which the questions were usually of considerable mechanical difficulty but unfortunately did not give the opportunity for the candidate to show mathematical imagination or insight or any quality that a creative mathematicians needs."* (See Foreword of [5].)

t_6 **Re-evaluation Course (2012–2013):** This can be considered a positive amendment despite being very expensive. It falls under Case (d).

t_7 **Mid-term Exams with New Exercises (2013–2014):** This amendment falls under Case (a) for the fall semester and year, and under Case (e) for the spring semester. It seems to be a situation to avoid if one looks only into the numbers. However, when related to the situation at t_5, it seems to confirm our perception that the students are learning in a more mechanical way. The values for the spring semester seems to confirm the impression that given more time students can adapt their learning to assume this kind of measures.

t_8 **Course Diversification:** This is a positive measure that falls under Case (c). Students become more interested in the new material and they seem to work harder, increasing consequently the pass rate.

8 Conclusions

In this paper we have described the evolution of the continuous assessment of the CS1 course. This evolution has been defined by the series of measures that have been taken to increase the pass rate since its inception. The successive introduction of these reported measures, as a way to incentive students' work, increased the weight of continuous assessment. However, the pass rate of this massive course has not increased as much as expected. In fact, we have seen that the increase of the faculty workload paralleled the increase of continuous assessment.

We performed a quantitative analysis of the temporal evolution of the pass rate/workload ratio of the evaluative activities as a method to assess the impact of the introduced measures. Our analysis is based on two functions: productivity and marginal gain. We use them to perform a cost-benefit analysis. The proposed method allow us to assess whether a measure should be maintained, tuned or withdrawn, under the general hypothesis that the current content of the course as well as the proficiency levels achieved by students who passed the course should not be changed. In particular it becomes clear that, for some of the adopted measures, the amount of invested resources (faculty workload) did not justify their impact in the pass rate. For instance, the substantial overhead of the measure of grading red verdicts had almost no impact on the passing rate. However, other measures did have a positive impact without increasing the workload, as for example, the weights given to the different exams. Moreover, as all the introduced measures involve continuous assessment, our study shows that the corresponding workload is close to its limit.

The analysis tools proposed in this study provide a way to analyze the effectiveness of new measures. Our findings are valuable for the design of future strategies for this and similar courses. Several pedagogical strategies, around the use of the online Judge as an automated aid to motivate, help and evaluate students, have been introduced in the CS1 course. Some of them have been successfully used also in other courses at our university (CS2, Data structures and algorithms, Algorithms, Functional programming, among others). It would be of interest to perform this kind of analysis for the evolution of the continuous assessment of those courses.

We have focused uniquely on the pass rate/workload ratio, however the scope of our study could be extended in other ways. As an example, taking into account students marks and motivation will provide a finer analysis which might bring more insights in the effectiveness of every measure.

A Technical Details

In this appendix we calculate the amount of working hours per task at each stage of our course based on the 14 answers that we obtained by surveying current instructors and extrapolating these values to previous timestamps. Note that most measures, once taken, remain in force, thus the workloads involved are accumulated.

t_0 **Kick-off (2006–2007):** The course started with two kind of lectures, theory and practical, of 3h per week each. Theory lectures were given to groups of 60 students, and the survey says that in average it takes 1.5h to prepare one hour of theory lectures. This results in a total of 2.5h of work (preparation + lecturing). Since the course is 15 weeks long, we have:

$$
\begin{aligned}
&T_{t_0} \text{ hours} = \\
&\quad (1+1.5)\frac{\text{hours}}{\text{1h theory}} \times 3\frac{\text{1h theory}}{\text{week} \times \text{group}} \\
&\quad \times 15 \text{ week} \times \frac{N_{t_0}}{60} \text{ group} \approx 1.7 \times N_{t_0} \text{ hours}
\end{aligned}
$$

where N_t is the total number of enrolled students at time t. Proceeding similarly for practical sessions and considering that the size of the laboratory groups is of 20 students, and that the preparation of each hour of practical sessions takes 1h, we have that $L_{t_0} = 2 \times 3 \times 15 \times \frac{N_{t_0}}{20}$.

There were two exams of 2 problems each. There were 2 turns of exams (morning and afternoon), all the students that have morning classes are examined with the same exam which is different from the exam of the afternoon students. So 4 problems should be prepared (2 per turn). Since each exam lasted for 2h and the students were distributed in laboratory rooms with 20 computers we have that $V_{t_0} = 2 \times 2 \times \frac{N_{t_0}}{20}$. We estimate that the preparation of each problem takes in average 3h of work (this include writing the statement, implementing the solution and designing the tests that the system requires to judge the submissions). Therefore, $E_{t_0} = 24$.

Only the solutions of students that obtained a green verdict for a problem were graded by hand, and this was, approximately, a third of the students, so $G_{t_0} = 2 \times 2 \times 0.2 \times \frac{N_{t_0}}{3}$ h, considering that grading one problem takes 12 min.

The coordination of the whole course has two parts. A fixed cost, estimated as 1h per week giving 15h, that is $k_0 = 15$. Another part depending on the number of students of each course. We estimate this last amount in one half hour per group of 10 students, then $C_{t_0} = k_0 + 0.5 \times \frac{N_{t_0}}{10}$. Finally, we are estimating that the software maintenance takes 4h a day yielding to $S_{t_0} = 4 \times 5 \times 15$ per course. As this period corresponds to a start-up, there is no redesign and therefore, $R_0 = 0$.

t_1 **Introduction of Quizzes (2007–2008):** In this period 4 small mid-term exams were introduced in addition to the two original exams and they were applied also in two turns. Considering that the time required to prepare each small exam was 1.5h and that the time required to grade the small exam of one student was 6 min, this measure increased E_t and G_t to $E_{t_1} = E_{t_0} + 4 \times 2 \times 1.5$ and $G_{t_1} = 4 \times 0.3 \times \frac{N_{t_1}}{3}$. The workload of all the other tasks remained the same. There is no redesign, $R_1 = 0$. We also take $k_1 = k_0$

t_2 **Grading Red Verdicts (2008–2009):** When all the submissions (and not only the green labelled ones) have to be graded G_t was triplicated. $G_{t_2} = 4 \times 0.3 \times N_{t_2}$. We take $k_2 = k_0$ and $R_t = 0$.

t_3 **Hand-written Final Exam (2009–2010):** At this point the final exam was changed to be a written exam of 3 problems. The exam was organized in only one turn applied to all the students (same exam for all students).
The time to prepare a problem for a written exam is estimated in 2h (1h less than the time of a practical exam). Therefore $E_{t_3} = E_{t_1} - 2 \times 2 \times 3 + 3 \times 2$. The written exam lasts for 3h. Since rooms with place for 40 students where used for a written exam, V_t decreased to $V_{t_3} = 2 \times \frac{N_{t_3}}{20} + 3 \times \frac{N_{t_3}}{40}$. As before $k_3 = k_0$ and $R_3 = 0$.

t_4 **New Degree (2010–2011):** The fix cost due to bureaucratic duty in increases from k_0 in an extra half an hour per week plus 2h of exam coordination giving $k_4 = k_0 + \frac{1}{2} \times 15 + 2 = 24.5$. With the new degree the hours of theory lectures per week decrease from 3 to 2 per group yielding $T_{t_4} = 2.5 \times 2 \times 15 \times \frac{N_{t_4}}{60}$. The course redesign R_4 increases. As the 15 sessions shrink in 1h, a main redesign of the contents is needed. The estimated cost is 3h per session giving $R_4 = 3 \times 15 = 45$. The evaluation system also changed. The big mid term exam disappeared. The four small mid term exams became formal exams of one problem each. Thus, $E_{t_4} = 4 \times 3 \times 2 + 2 \times 3$. The first 3 mid term practical exams lasts 1.5h each while the last one for 2.5h. The final exam still lasts 3h, thus $V_{t_4} = (3 \times 2 \times 1.5 + 2 \times 2.5) \times \frac{N_{t_4}}{20} + 3 \times \frac{N_{t4}}{40}$.

t_5 **Lists of problems to hand-in (2011–2012):** A list of problems per exam to be delivered by the students before the exam was introduced. The problems of the exams were chosen from the problems of the list. The preparation of each laboratory problem decreased to 1.5h. Hence $E_{t_5} = 4 \times 2 \times 1.5 + 3 \times 2 = 18$. $C_{t_5} = k_4 + 0.5\frac{N_{t_5}}{10}$. Finally, the preparation of the lists set up R_5 to 10h, so that $R_5 = 10$.

t_6 **Re-evaluation Course (2012–2013):** The k_5 increases by 2 coordination hours needed to manage of the re-evaluation, $k_6 = k_5 + 2$. The R_6 is increased by 6h because 3 new large lists plus the corresponding sessions has to be generated, $R_t = 16$. In this case $E_6 = E_5 + 2 \times 2 + 3 = 7$. Moreover we need to add 20h to T_t, 60h to L_t, 15h to G_t and 3h to V_t.

t_7 **Mid-term Exams with New Exercises (2013–2014):** This measure involved the creation of new problems for the mid-term practical exams, instead of taking them from the lists. This increased the time for preparing each problem from 1.5 to 3h. Thus $E_{t_5} = 4 \times 2 \times 3 + 3 \times 2 = 30$.

t_8 **Course Diversification** In this case $k_8 = k_7$. C_8 is computed as in the previous step. Other cases are similar. The big difference is in the course redesign. First of all, there is a fix part cost due to list redesign. New 15 list has to be build, with a cost of half an hour per list. The lab training of the new list, depends on the number of groups $N_8/10$, on the number of list and is also 1/2h. Therefore

$$R_8 = 1.5\frac{\text{hours}}{\text{list}} \times 15 \text{ list} + \frac{1}{2}\ \frac{\text{hours}}{\text{list} \times \text{grup}} \times 15 \text{ list} \times \frac{N_8}{10} \text{ grup} = 358.5 \text{ h}$$

The quantification of this model was provided in Tables 3 and 4.

References

1. Arrow, K.J.: The economic implications of learning by doing. Rev. Econ. Stud. **29**(3), 155–173 (1962)
2. Bowles, S.: Towards an educational production function. In: Education, Income, and Human Capital, pp. 9–70. National Bureau of Economic Research (1970)
3. Giménez, O., Petit, J., Roura, S.: Programació 1: a pure problem-oriented approach for a CS1 course. In: Hermann, C., Lauer, T., Ottmann, T., Welte, M. (eds.) Proceedings of the Informatics Education Europe IV (IEE 2009), pp. 185–192 (2009)
4. Hanushek, E.A.: Education production functions. In: The New Palgrave Dictionary of Economics. Palgrave Macmillan (2008)
5. Hardy, G.: A Mathematicians Apology. Cambridge University Press, Cambridge (1940). Reprinted with Foreword by C.P. Snow 1967. Cambridge University Press, Canto Edition (1992)

6. Ihantola, P., Ahoniemi, T., Karavirta, V., Seppälä, O.: Review of recent systems for automatic assessment of programming assignments. In: Proceedings of the 10th Koli Calling International Conference on Computing Education Research, pp. 86–93. ACM (2010)
7. Martín-Carrasco, F.J., Granados, A., Santillan, D., Mediero, L.: Continuous assessment in civil engineering education – yes, but with some conditions. In: Proceedings of the 6th International Conference on Computer Supported Education, Barcelona, vol. 2, pp. 103–109. SciTePress (2014)
8. Petit, J., Giménez, O., Roura, S.: Jutge.org: an educational programming judge. In: Proceedings of the 43rd ACM Technical Symposium on Computer Science Education, SIGCSE 2012, pp. 445–450 (2012)
9. Revilla, M., Manzoor, S., Liu, R.: Competitive learning in informatics: the UVa online judge experience. Olympiads Inf. **2**, 131–148 (2008)
10. Solow, R.M.: Learning from 'Learning by Doing' Lessons for Economic Growth. Kenneth J. Arrow Lectures. Stanford University Press, Palo Alto (1997)
11. Stiglitz, J.E., Greenwald, B.C.: Creating a Learning Society: A New Approach to Growth, Development, and Social Progress. Kenneth J. Arrow Lectures. Columbia University Press, New York (2014)
12. Tonin, N., Zanin, F., Bez, J.: Enhancing traditional algorithms classes using URI online judge. In: 2012 International Conference on e-Learning and e-Technologies in Education, pp. 110–113 (2012)
13. Varian, H.R.: Intermediate Microeconomics: A Modern Approach, 7th edn. W. W. Norton and Company, New York (2005)
14. Verd, E., Regueras, L.M., Verd, M.J., Leal, J.P., de Castro, J.P., Queirs, R.: A distributed system for learning programming on-line. Comput. Educ. **58**(1), 1–10 (2012)

A Flipped Classroom with and Without Computers

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Abstract. Flipping a classroom involves a more interactive class model where students and instructors spend the majority of the class time on various interactive activities in engagement with class materials. Often, this pedagogy style involves taking advantage of the new interactive technologies. In this work, we describe an experiment in an introduction to programming class (CS1) in which we compared the outcomes of offering the same interactive classroom with and without computers. The first approach required students to bring computers to class to engage with the class and materials individually and in groups using the computer-enabled tools. The other approach was to ban computers and require students to interact in person and engage with materials using pen and paper. In both approaches the students' attempts are shared with the class and discussed, and in general we attempted to maintain the same class models. We found that the use of computers alone had no statistically significant effect on the students' learning outcomes, enjoyment of the material, self-assessment of their understanding, use of teaching assistant resources, or self-estimate of how many hours they invested outside of the classroom. We did find that a statistically significant number of students preferred in-class engagements and interactions using computers. We also found that the instructor had much more useful and detailed information about individual student's interaction in class when computers were used. We conclude that, although many instructors are wary of requiring computer use in large classes, there is evidence that students prefer it, it does not negatively affect learning outcomes, and with appropriate tools and pedagogy, it gives the instructor a much deeper and more nuanced view of student performance in the class.

Keywords: Flipped classroom · Blended learning · Computer-mediated-communication · Pedagogy design · Teaching introductory computer science · Educational technologies · Web-based ides

1 Introduction

There is a growing body of evidence which demonstrates that active learning pedagogies improve learning outcomes in a wide variety of courses, including introductory programming courses [2, 3, 10]. It is very natural to allow students to use their laptops in class during active learning sessions of an introductory computer science course. Many faculty,

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however, are wary of requiring computer use during class sessions since they feel students might become distracted.

In recent years we have seen many new developments in the way teaching and learning are accomplished inside and outside of the classroom. The last decade has seen research, development and adoption of new pedagogies, classroom technology and software applications. One such new pedagogy technique has been the 'inverted' or 'flipped' classroom in which static content is covered outside of class (through readings or videos) and class time is devoted to more interactive and engaging activities. Even though most approaches have leveraged the ubiquity of technology, flipping a classroom does not necessarily require the use of computers or other networked technology.

In this work we present our case study of partly-flipping a large CS1 class. The course was an Introduction to Programming in Java and C in which we used a partly-flipped pedagogy that combines both in-class lectures and in-class programming challenges often using a Think/Pair/Share technique [7]. Since the course was taught in two sections (of about 150 students each), we were able to design an experiment to evaluate the effect of two approaches to partly-flipping the classroom. The first approach is to require all students to bring a laptop or tablet to class and use their computers for various interactions, to answer questions and to solve coding challenges. The second approach is to ban computers from the classroom and to require students to solve problems with pen and paper and to be prepared to present and discuss their solution to the class if called upon.

In the computer-mediated sessions, students used two web-based applications, TeachBack [6] and Spinoza [1], to interact with the instructor and the other students while solving programming. In the non-computer sessions, we endeavored to replicate the same pedagogy using pen, paper, blackboards and the instructor's computer projected on a screen. Both sessions covered exactly the same material and used exactly the same pedagogy. Students received nearly identical lectures and were given the same programming challenges. The only difference is that in one section students were allowed to use their computers to solve the programming problems, while in the other section they had to use pen and paper only.

In the following sections we present the experimental design that was used to compare the computer and non-computer approaches to the pedagogy. We then proceed to describe the pedagogy used and we compare the way it was implemented using the computer-mediated and pen-and-paper based approaches. Finally, we present the results of the experiment and discuss its implications for computer use in the partly flipped introductory programming classroom.

2 The Experiment

Introduction to Programming in Java and C is the first course in the Computer Science major in our department. Students who performed well in an equivalent CS1 course in high school may skip the course, but all other potential majors are required to take it. It was taught in two sections (self-selected by the students). One section had 136 students and the other had 148. Both sections had the same instructor, exams, homeworks, teaching assistants, and daily lesson plans. For both sections, we provided screen recordings of each class that students could review at their leisure.

The course was divided into 4 units, each lasting about 3 weeks. Each unit culminated in a 90-min exam that provided a summative assessment of student mastery of the material for that unit. In the first two units students were required to bring their computers to class and to interact with the instructor using TeachBack and Spinoza. Ten percent of their final grade was based on the number of TeachBack formative assessment questions they answered (whether the answers were correct or not). During Units 1 and 2, students were required to bring computers to class and use them to interact with the instructor and their peers. During Unit 3, computers were banned from Sect. 1 while still being required in Sect. 2. During Unit 4, the protocol was reversed: computers were required in Sect. 1 and banned in Sect. 2. This provided us with two units of control in which both sections used computers, and two experimental units where one section required computer use and the other banned its use.

3 The Active-Learning Pedagogy

Before each week of classes students were assigned topics or subtopics to read and as a weekly homework they were asked to submit a short reflection on what they learned and to discuss any confusing ideas in the reading. Each class had lectures intermixed with class-wide interactive activities. The lectures involved PowerPoint slides, notes from the class website, live coding demonstrations by the instructor, and visits to various websites. The interactive activities included short answer questions as well as programming challenges.

In this section we discuss the main pedagogical techniques used in the two versions of the class and along the way we introduce the TeachBack and Spinoza tools. TeachBack [6] is a web-application with three main features: a supervised back-channel forum (called the Forum) where students can ask and answer questions with each other and with TAs who are always present during classes, a pie chart and timeline plot (called the Feedback) where students can indicate if they are confused, engaged, or bored and can include a 50 character explanation of their affect and cognition (i.e. emotional and comprehension) states, and a clicker-type application (called the iResponder) which allows the instructor and TAs to collect and grade student answers to formative assessment questions during the class. Spinoza [1] is a web-based Java IDE that allows students to solve simple programming problems online and provides the instructor with a real-time view of the progress of the class with similar solutions grouped together.

3.1 PowerPoint Lecture Activity

Although the students were required to read the text before class, we often began a class with a PowerPoint overview of the main ideas presented in the readings. In the computer-based version of the class, students could view the PowerPoint slides on their computers and ask questions of the teaching assistants using the TeachBack Forum. In the pen-and-paper version they could print out the slides on paper before class and ask questions by raising their hands, which interrupted the class flow.

In the computer-mediated version of the class, we used a web-based Integrated Development Environment.

3.2 Live-Coding Activity

Another lecture-style activity is when the instructor solves or demonstrates a programming problem using a Java IDE and the class watches (or in the computer-mediated version, follows along). This can be made interactive by asking students to provide suggestions for how to solve the problem. In the computer-mediated version when students are following along with the coding using Spinoza and they encounter syntax errors they can interact with the TAs using the TeachBack Forum without interrupting the class.

3.3 Answering Student Questions During Class

In both versions of the class, students were encouraged to ask questions if they were confused. In the pen-and-paper version, students would raise their hands and engage with the instructor while the class paused. In the computer-mediated version, students used the Forum feature of TeachBack to ask questions online, and have their questions answered by TAs assigned to the course, or sometimes by other students who were monitoring the forum. The instructor would briefly review the forum with the class at the end of most activities.

3.4 Posing Questions for Students to Discuss and Answer

After a lecture activity, we would usually pose a series of questions and ask the students to think for a minute about a solution, then to talk with their neighbors about their solution, and finally to share their solutions with the class. Typical examples would be predicting the result of evaluating a snippet of code, or finding a bug in a piece of code shown on the projector. In the computer-based version, we used the iResponder feature of TeachBack. Figure 1 shows a typical activity in which the instructor projected a method on the screen and asked students to predict the return value for various calls. iResponder allows the instructor and TAs to not only see the solutions (grouped) but to grade them and assign points and comments. Once a sufficiently large number of students have submitted an answer, the instructor reviews the most common solutions and leads a short class discussion on the different approaches and the different kinds of errors. In the pen-and-paper version, it is difficult to determine how many students have completed the activity and it is hard to tell what the most common solutions and errors were. Students were motivated to solve problems in the pen-and-paper class by randomly selecting students to describe their solutions (possibly on the board or typing into the instructor's computer).

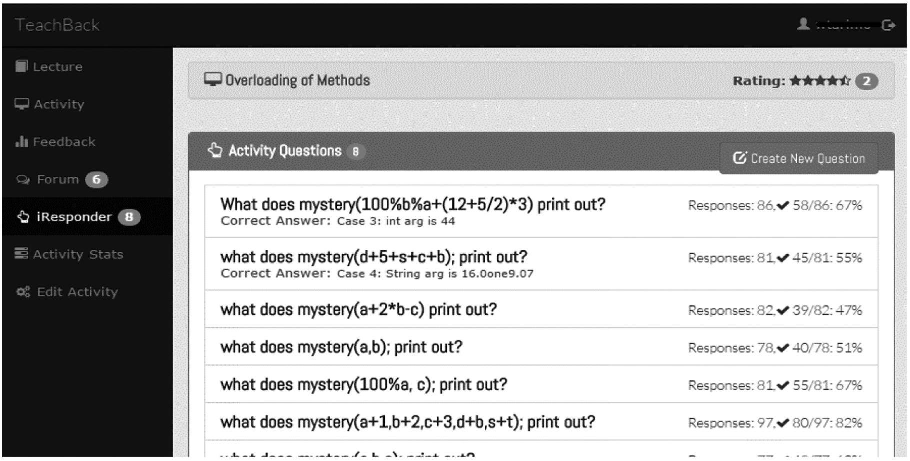

Fig. 1. A typical iResponder screen in TeachBack.

3.5 Programming Problems

In this activity, students are given a programming problem and asked to think about how they would solve it and then work with their neighbors to come up with a solution. For example, students could be asked to write a method with three integer parameters that returns true if the parameters all have different values.

In the computer-mediated version of the class, we used a web-based Integrated Development Environment (IDE) called Spinoza that allows instructors to quickly create a programming problem. Figure 2 shows the student view of a Spinoza programming problem which provides a description of the problem on the left, some initial scaffolding code in the center, a "Run" button below, space for the output on the right, and the results of an instructor supplied set of unit tests at the bottom. Students can then write, run, and debug the problem using the web-based IDE. Spinoza has an instructor's view which shows the number of students that have hit the "Run" button and it groups the programs together based on a similarity function (ignoring white space, variables names, etc.). The instructor can see in real-time the most popular proposed solutions to the problem and can view and debug those solutions in front of the class. The debugging process itself can be formulated as a Think/Pair/Share model [7], where students try to find and discuss the bugs (both syntactic and logical) in small groups before sharing with the class.

In the pen-and-paper version of the class, programming problems are displayed on the screen and students are asked to write their solutions on paper. The instructor then randomly selects students to share their solutions. The disadvantage of this approach is that the instructor doesn't know what the most common solutions or errors are and the process of sharing a solution with the class is more time consuming.

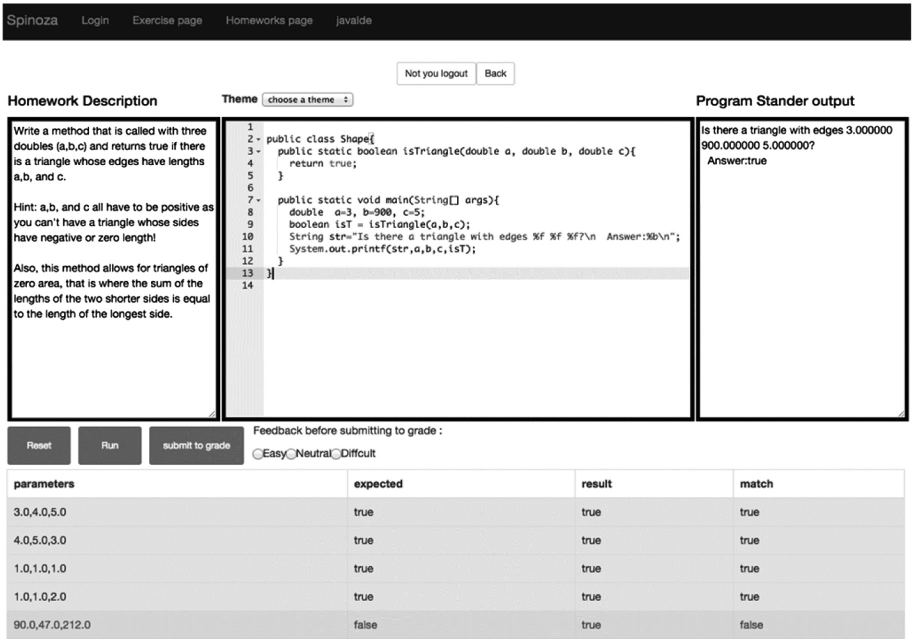

Fig. 2. The student view of a Spinoza problem.

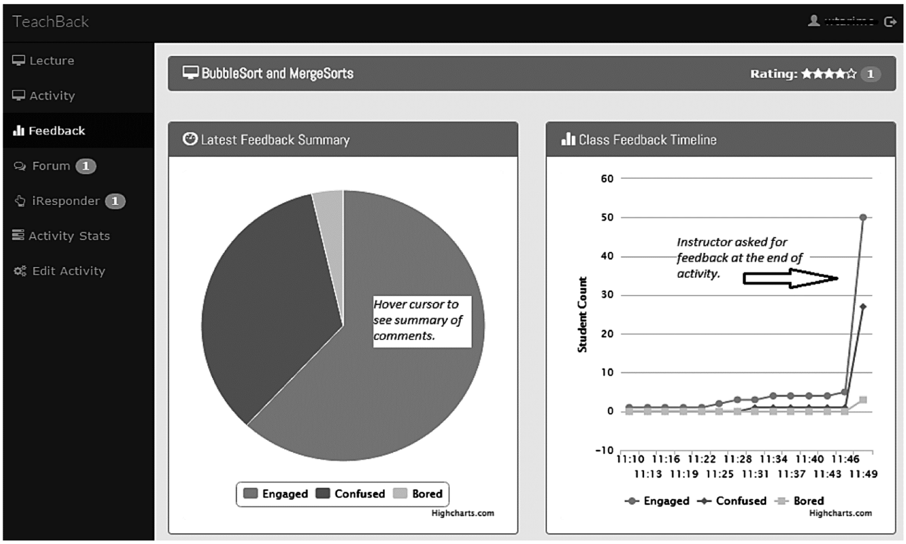

Fig. 3. The Feedback tool in TeachBack.

3.6 Feedback

After new material has been introduced we often ask the students for feedback, typically at the end of an activity or class. We ask whether they are confused, bored, or engaged by the material and also ask for a short comment. In the computer-mediated version, this is done using the TeachBack Feedback feature, which displays a pie chart showing the three responses (Fig. 3). Hovering over one of the pie slices reveals a list of the comments students provided. We often find 20 %–50 % of students report feeling confused when a class introduces new material (e.g. arrays or the for-each loop). This provides an excellent opportunity to reassure them that it is natural to feel confused when learning new material. The comments also show what confused them or expand on their affect. At this point the instructor also clarifies the various confusion issues. Since it is so easy to get and analyze feedback from students using TeachBack, we often get feedback after each activity in a single class. TeachBack also provides an instructor/TA view of the daily progress of individual students using performance and participation statistics at an activity, lecture and course levels.

In the pen-and-paper version, we ask students to put this information on a small card or piece of paper, which is then reviewed by the instructor after the class. One disadvantage of this approach is that we can't report the results until the following day and it can take 30 min to an hour to read through a few hundred separate comments.

4 Data Collection

After each unit, students were asked to complete a survey where they self-assessed their level of understanding of the material in that unit as well as their level of enjoyment of the material in that unit. In units 3 and 4 they were also asked to rate each of the different styles of pedagogy employed in terms of its effectiveness for their own learning.

We kept track of the number of students from each section that visited TAs during each of the units and asked students to estimate how many hours they spent working on the course outside of class. We also kept track of each student's participation in various components of TeachBack during each class, each unit, and the semester. Finally, grades on the four unit quizzes as well as course grades were used to measure mastery of the material by unit and over the entire course.

5 Results

We found four main results from our analysis of the data which we discuss below:

5.1 The Use of Teachback/Spinoza in Class Does Not Harm Learning Outcomes

In Units 1 and 2, both sections used computers in class. In Unit 3, computers were banned in Sect. 1 and required in Sect. 2. In Unit 4, the reverse policy held, computers were required in Sect. 1 and banned in Sect. 2. We found that there were no statistical differences between the two sections during those units in terms of quiz scores, student satisfaction, student self-assessment of understanding, or student use of teaching assistants. From the surveys at the end of each unit, students self-reported their levels of learning and satisfaction in the range [1–5]. As seen in Figs. 4 and 5, the averages on each section do not indicate any significant influence from the changes of pedagogies in units 3 and 4.

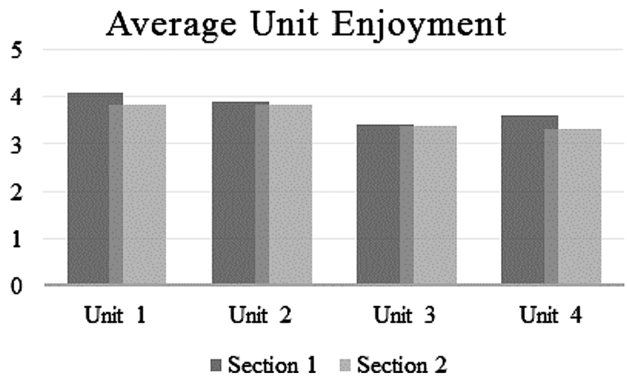

Fig. 4. Average perceived enjoyment.

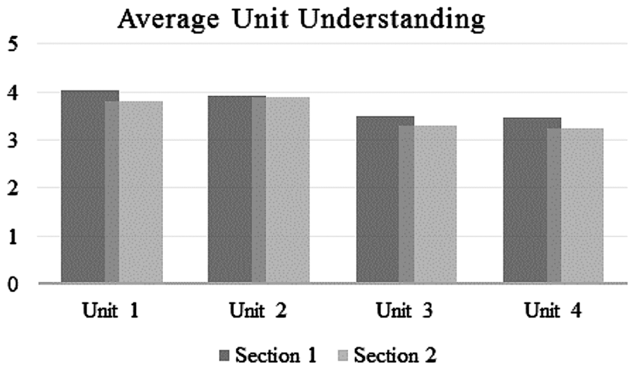

Fig. 5. Average perceived understanding.

Section 1 generally indicated a higher level of enjoyment, understanding, and mastery than Sect. 2, for all units, but that increased level of understanding was not statistically significant.

For example, in Fig. 5, the difference between the average understanding in unit 3 between Sects. 1 and 2 was 0.17 but the p-value for the two-tailed unpaired T-test for those means was 0.20 which is not significant. Likewise, in Fig. 4 the difference of average enjoyment for unit 4 between Sects. 1 and 2 was 0.23 but the p-value was 0.12, again indicating no significant difference. None of the apparent differences in Sects. 1 and 2 shown in these three figures was significant at the 0.10 level.

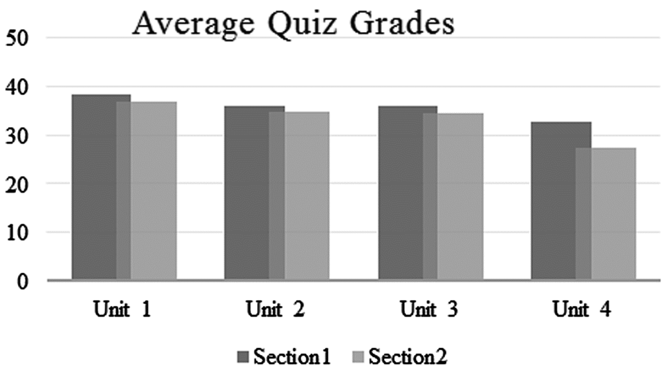

Fig. 6. Average end-of-unit quiz grades.

If use of computers was especially distracting, we would expect to see Sect. 1 outperform Sect. 2 in Unit 3, and the opposite occur in Unit 4. Likewise, if the use of computers was highly beneficial we would expect Sect. 2 to outperform Sect. 1 in Unit 3, and the reverse in Unit 4. No such effects were found (Fig. 6).

5.2 Most Students Prefer Using Computers in Class

When asked about the two different styles of active learning - writing programs with your neighbors on paper versus writing programs on your computer while talking with your neighbors, the use of computers was thought to be more effective and the results are statistically significant. Students used a five point scale to rank effectiveness of learning from 1 = not effective to 5 = very effective. Solving programming problems with friends using pen-and-paper was ranked at 2.96/5 and solving programs using Spinoza with friends at 3.65/5 with a difference of 0.69. This is significant at the 0.001 level using a two-tailed paired T-test. The 95 % confidence interval of the difference is 0.5 to 0.88.

Below are some typical comments from students after unit 4. Here is a Sect. 1 student, happy to be able to use his computer again in class:

– "I really enjoyed when we got to live code in class. It was helpful to either follow along with what [the professor] was typing or work on building up the program with the people around us. It allowed me to see what thought process has to go into building up a program."

And here are comments from students in Sect. 2 explaining why they were disappointed about not being able to use computers in class:

– "The lack of computers makes following along a lot less interesting and understanding class material becomes much more difficult."
– "Taking notes on paper and not being able to practice coding in class slowed down acquisition of the material greatly. It [took] much longer for this unit than others to master the material. I also disliked being asked to work in teams or to talk to people in class, but that's because I'm shy …"

– “We can’t use computer[s] to do real-time programing in class. To make it up, I have to go back home and watch the class recordings to brush my memory on what programing topics we went through in class that day. It is really time consuming.”

5.3 Some Students Were Distracted by Computers in Class

A close examination of the student comments about each unit demonstrated that there was a group of students who did not feel they learned as well with computers as they did without. Indeed, a few students would attend the lectures from the other section when the pedagogy was switched because they felt they could not learn well when required to interact with a computer in class. These were mostly students who reported being easily distracted in general. Below are some comments from students indicating what they liked about unit 4 when computers were not allowed.

– “Not using a computer, it lead me to better concentrate.”
– “Not being allowed to use our computers helped for concentration and focus.”

Most students, however, didn’t report being distracted by the use of computers in the class, contrary to the worries of many instructors. This observation is largely due to the nature of the pedagogy. The division of the class time into short interactive activities allowed students to always be engaged with the material, their peers or the instructor. There was no time for students to get side-tracked into distraction with non-class related endeavors.

5.4 Students Generally Approved of the Active Learning Approach

In general, students appreciated the pedagogy used in the class, whether or not we were using computers. Here are some illustrative comments.

– “The class was very lenient towards our learning and it’s a great feeling to know that the teaching staff is very forgiving for us ‘newbies’. Learning is the number one goal.”
– “I was forced to try to learn the material to the best of my ability beforehand to be as prepared as possible whether or not I was using my computer or notebook.”

6 Discussion

One of the main goals of the experimental design was to be able to test the effects of the use/non-use of computers in a CS1 class in a way that removed as many possible confounding variables as possible. Therefore, both sections had the same instructor, the same course plans for every day, and each section had an exposure to a unit where computers were banned while computers were required in the other section.

We observed that the students in Sect. 1 did better in all four units than the students in Sect. 2 in terms of quiz grades, self-estimation of understanding, and level of enjoyment of the course. Section 1 was an earlier class (11:00) and Sect. 2 conflicted with some other large classes (e.g. Intro to Economics). Therefore, the two populations of students may have been qualitatively different, e.g. early-risers with a tendency to take Economics courses. If we had taught Sect. 1 without computers and Sect. 2 with computers, then the fact that Sect. 1 had "better" students would have made it more difficult to tease out any potential effect of the treatment (banning versus requiring computers in class).

Our experimental design did allow us to show that in a class in which computer-use was alternately required and banned, the student performance was not different (in a statistically significant way) in the two kinds of units. On the other hand, this experimental design also tended to hide some potential effects that might appear in an experiment where treatments don't alternate and multiple sections are assigned to computer-banned or computer-required treatments for the entire semester. In fact, we suspect that active-learning CS1 classrooms in which students are required to use TeachBack and Spinoza (or similar computer-based classroom technologies) for the entire semester may indeed have better learning outcomes than active-learning CS1 classroom that ban computer use. In this section, we provide some arguments in support of this claim.

The simplest critique of our experimental design is that although there was no statistically significant effect on the learning outcomes, it could be because the students in the computer-required (or the computer-banned) section may have had to work much harder to achieve the same performance as they did in the other section. We had one student, quoted above, who said they went back and reviewed the screen recordings every day during the computer-banned units so they could follow along with their computer and this took an enormous amount of time. It is hard however to accurately estimate how much time students are spending outside of class without some sort of automatic time-keeping protocol.

We hypothesize that the TeachBack Feedback mechanism in which students report if they are bored, confused, or engaged and then see the results for the entire class may have a beneficial effect on the students by easing their anxiety about being confused. When they see that half of the class is regularly confused when new material is introduced they may feel less fearful and anxious and hence be able to learn more effectively. In our experimental design both sections started out with 2 units of computer-required classes and hence both benefited from this effect, if it was indeed present. Similarly, when students use Spinoza to solve programming problems in class and then are able to see that many other students in the class are making the same mistakes, we suspect that this can also reduce anxiety and improve learning effectiveness.

Another drawback of our experimental design is that it doesn't allows us to see if mandatory computer-use in class has any effects in future classes, e.g. does it improve retention in future CS courses (or not), do students in a computer-required course perform better (or worse) in the follow on courses. In our experiment both sections had three units in which computer-use was mandatory in class, and one unit in which it was banned. Any benefits either approach has over the other are averaged out over the semester and hence the experiment does not have any different impact on the two classes in years to come. This makes it impossible to study longer-term effects of computer use in the classroom.

Finally, since the protocol required that both courses use exactly the same pedagogy to the extent possible, we were not able to use the highly detailed and nuanced information that we had collected using TeachBack and Spinoza to find students who were at risk of doing poorly and target additional resources to them. In the computer-banned version of the course, the only way to assess student performance with our experimental design is through the homework and quiz grades. The quiz grades do indeed show who is doing poorly, but by then it is too late as quizzes are summative assessments. The homework grades are unreliable as they don't show how much time students spent on the homework, nor how much help they received from friends or teaching assistants, nor what kinds of mistakes they were making when completing the homework. If a struggling student works hard enough and gets enough help, his or her homework can be nearly as good as the student who is doing well. TeachBack and Spinoza on the other hand capture much more information and can give daily snap-shots of student understanding at a much deeper level of detail.

7 Related Work

Amresh et al. [2] performed a recent study involving flipping an introductory computer science class, where students would watch prepared lecture videos before classes, and have interactive discussions in class. Through summative assessments, this flipped model was found to produce higher average test scores. However, due to many years of traditional classrooms, students found this new approach to be overwhelming at times, especially as the videos and reading became boring and less engaging. In regard to this, Bates and Galloway [3], point out that successful flipped classes require the acceptance and embracing of this new unstructured and contingent lecture approach where the instructor is a coach of learning. In this case study in an introductory physics class; students were assigned pre-class readings and quizzes, and class meetings involved discussions driven by clicker questions. An important factor for success is to have access to or create sufficient clicker questions for good discussions. If students can be motivated to complete the work outside of class, flipped classrooms can enable more and deeper understanding without necessarily covering less content. Since students are more exposed to the materials in pre-class and in-class activities, the flipped pedagogy has the advantages of developing life-long learners, increasing engagement during classes, and increasing interactions among students and the instructors [10].

Systems similar to the Spinoza system used in this study have been developed to facilitate teaching introductory programming classes. JavaBat [8] is a web application that helps students to build coding skills by providing immediate feedback to small problems in which they write code for the bodies of single methods. The system generates several tests (handwritten by the instructor) and shows students the results of those automatic tests. Students can specify a teacher who can then see their work and follow their progress, but the teacher cannot write comments or otherwise communicate with the students through the tool. Another system is Informa [5], a clicker software system for teaching introductory programming with Java. Informa has been used in flipped classrooms as a way to support active learning of programming skills. It supports several different types of questions, including problems requiring students to write Java code, but it does not run the students' code and it is not web-based, it requires a Java app to be downloaded and installed. It also allows students to download and comment on other students' solutions. Spinoza allows instructors and TAs to view and comment on student programs, but does not currently allow students to comment on other students' code.

8 Conclusions

Our findings demonstrate the critical part played by the pedagogy in a classroom. As we pursued the same interactive pedagogy with and without computers, we were able to support two main results. First, the class can be taught using essentially the same thought and learning processes with or without computers. Secondly, contrary to most beliefs, allowing computer-use in class on its own causes distractions and poor learning outcomes for only a small subset of students. Those students could perhaps be given accommodations to not use their computers in class. Finally, this study therefore demonstrates that the use of computers in this class does not affect learning outcomes in any statistically significant way.

The key factor in student learning is the pedagogy itself. The highly interactive pedagogy we used encouraged students to maintain high levels of interaction, engagement and motivation with the material whether they used computers or not. We know from previous studies that active learning in flipped classes is a more effective pedagogy than straight PowerPoint lectures [2] and the results from this paper suggest that this pedagogy can be delivered either with or without a computer.

The various avenues of interaction offered by tools like TeachBack and Spinoza offer increased participation and involvement rates. But that is not all, like most computer-mediated communication tools, TeachBack and Spinoza allow content and conversations to be stored and accessed at later times. Both of these tools closely record students' participation and performances across the various interactive tools. For instance, in TeachBack, these statistics are both aggregated and viewable at the activity, lecture and course levels, enabling close monitoring of students' progress in the class. Moreover, this information is individually provided for each student. Non-summative assessment data of this nature can be useful in early detection of students in trouble as well as provide new avenues to learn best how to carter to students' learning needs.

In addition, participants do not have to be in the same physical locations, and users can engage in multiple conversations at once. In a way, these tools liberate learning and teaching from constraints of time and distance [6, 9] where barriers such as distance, disabilities, shyness and cultural difficulties are overcome. Our proposed computer-mediated pedagogy features various interactive and engaging activities that do not give students the opportunities to get distracted. However, as we have discovered in this study, there are a few students who are ill equipped to handle computer-mediated interactions and online environments. Our results suggest that it might be worthwhile to offer two versions of the CS1 class, one which is fully computer-mediated providing the instructor with high quality and timely information about student performance, and one that is not computer-mediated to accommodate those students who are prone to distraction when given access to a computer in class. Another alternative approach is to teach a hybrid class, where computers are only allowed during certain in-class activities and are banned at other times, or to give accommodations to students who are highly distractible and have them work without computers in class.

9 Future Work

From the instructors' point of view, the use of computer-mediated pedagogy does have many benefits. As mentioned above, it provides a detailed record of the activity of each student in the class including which questions they answered, whether their answers were correct, how they tried to solve a programming problem, what their level of confusion was during and after each activity, etc. In this experiment, we did not use this additional data to customize our support for individual students in the class. We strongly suspect that this detailed information about individual students could be used to provide individualized support for at-risk students in a way that would make a statistically significant difference in learning outcomes. In our future studies we plan to test this hypothesis, where we will add early detection and notification functionalities that would enable to the ultimate goal of providing needed early support to students in need. We also plan to analyze our data after the fact to see whether it we are able to accurately predict which students do poorly in the course based on this fine-grained data from TeachBack and Spinoza.

We also plan to rigorously compare various interactive pedagogies which mix mandatory computer-use and mandatory non-computer use in the same class. For example, a few students commented about being distracted with extended computer use or at times preferring traditional lecture activities. We plan to design experiments to compare the effectiveness of three types of classes: those in which computers are required the entire semester, those that ban computers the entire semester, and hybrid classes in which computer use is sometimes required and sometime banned, possibly even during a single class session.

Based on the successes of iResponder in facilitating quick formative assessment questions where students respond individually, we plan to add the functionality for group questions where students would respond in small groups. The goal is to encourage more supportive and motivational peer discussions in smaller groups. Such a feature would make it easier to run Think/Pair/Share exercises and track the effect of sharing on changing students answers. Moreover, there are many ways of forming these discussion groups and therefore it will be a good framework to compare the effectiveness of these various techniques in forming student groups.

Finally, we are planning to build SOTL tools into TeachBack and Spinoza that will allow the instructor to tag certain days by the pedagogy used and then automatically test for statistically significant differences in the in-class student performance. The goal would be to encourage faculty to think about ways they could vary their pedagogy and then easily look for any differences in learning outcomes.

References

1. Deeb, F.A., Hickey, T.J.: Spinoza: the code tutor. In: Proceedings of the International Conference on Computer and Information Science and Technology, Ottawa, Canada, 11–12th May 2015
2. Amresh, A., Carberry, A.R., Femiani, J.: Evaluating the effectiveness of flipped classrooms for teaching CS1. In: 2013 IEEE Frontiers in Education Conference (2013)

3. Bates, S., Galloway, R.: The inverted classroom in a large enrolment introductory physics course: a case study. In: Proceedings of the HEA STEM Learning and Teaching Conference, April 2012
4. Erlich, Z., Erlich-Philip, I., Gal-Ezer, J.: Skills required for participating in CMC courses: an empirical study. Comput. Educ. **44**(4), 477–487 (2005)
5. Hauswirth, M., Adamoli, A.: Solve and evaluate with Informa: a Java-based classroom response system for teaching Java. In: Proceedings of the 7th International Conference on Principles and Practice of Programming in Java (PPPJ 2009) (2009)
6. Hickey, T.J., Tarimo, W.T.: The affective tutor. J. Comput. Sci. Coll. **29**(6), 50–56 (2014)
7. Kagan, S.: The structural approach to cooperative learning. Educ. Leadersh. **47**(4), 12–15 (1989)
8. Parlante, N.: Nifty reflections. SIGCSE Bull. **39**(2), 25–26 (2007)
9. Reed, A.: Computer-mediated communication (CMC) and the traditional classroom. Teach. Technol. Today **5**(6) (2000). https://web.archive.org/web/20140909135416/http://www.uwsa.edu/ttt/reed.htm
10. Stone, B.B.: Flip your classroom to increase active learning and student engagement. In: Proceedings from 28th Annual Conference on Distance Teaching and Learning, Madison, Wisconsin, USA (2012)

Computational Thinking: A Tool to Motivate Understanding in Elementary School Teachers

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Abstract. The need for teachers of Elementary School children to learn to program or rather to understand the Computational Thinking behind programming has been accelerated in many countries by the mandated teaching of programming in this context. A major problem is that the majority of such teachers have no concept of how to program and naturally are not motivated to learn programming. The need to teach programming will motivate most but to learn through a tool that can be seen to have intrinsic value in their role as teachers have a greater potential. This paper describes the design and early implementation of a tool to use the learning of Flash Action Scripting as a motivational mechanism for trainee teachers. The intrinsic value to them is intended to be the utilisation of the learned Action Scripting skills to produce their own teaching material. Initial results indicate an enhanced engagement and motivation to learn to program and improved confidence in doing so.

Keywords: Computational thinking · Flash action scripts · Trainee teachers

1 Introduction

With the increasing level of use of computers in all aspects of human lives from the almost invisible use in domestic appliances to the now nearly ubiquitous use of smart phones in communication, the need to produce more programmers has never been greater. For the software industry from the smallest start-up to the major development organisations such as Microsoft and Apple the need for new staff outstrips the supply. As a result the leading software developers have been putting pressure on governments worldwide to come up with plans to increase the numbers of programmers produced by their education systems. It is felt that much of what has previously been taught in what is called Information Communications Technology (ICT) in schools only led to frustration for those who were looking to develop an understanding of computing [5]. In the UK the pressure for more teaching of computing has led to a number of different initiatives. Starting with secondary schools the teaching of programming has now been mandated in UK schools. The same is happening in Malaysia; with an increased desire for more programmers to be developed there is now a need for greater levels of understanding of this process among teachers. However, those who are attracted to teaching as a career seldom come from the group who have a high level of computer programming exposure. Many (including those we have worked with in our experiments and are quoted

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in later sections of this paper) find the idea of learning to program "frightening" and this does not help them to be motivated to learn, even though they are aware that they will be called upon to support this learning in their classroom. For this reason there have been numbers of initiatives to enable teachers at all levels to engage with learning how to program themselves and thus be more ready to teach the subject. The generalist nature of teaching in elementary schools has already meant that earlier programmes to promote maths and English teaching in elementary schools has required retraining programmes for teachers in those schools and further development of subject specialist teachers in those schools and school districts [15]. In the UK the Computing at Schools initiative (CAS) has developed with a similar aim of enabling the teaching of computing and especially programming in schools. At first this attracted secondary school teachers who were already involved in the teaching of the existing IT courses in those schools. Increasingly these efforts are now aimed at elementary teachers and the background of these teachers requires a different level of learning.

Much of the work done to introduce programming concepts has concentrated on how to develop understanding of programming in young children. The Scratch language has been used successfully in this area [7, 11] as has the use of Python [1, 2]. The former uses a symbolic drag and drop interface that allows programming constructs to be easily put together in a visual way. The focus of the programs produced is often on controlling visual features such as computer sprites and producing games from these. Such things tend to be attractive to children who like playing games and thus become motivated by the idea of producing their own. However, teachers on the whole are less motivated by this and indeed the majority, like those in the experiments we have undertaken, find little motivation to learn to program from these initiatives. The concept behind the research in this paper is that teachers need to be able to see intrinsic value in learning to program in order to lose their fear of learning the process. We have proposed that by learning Flash Action Scripting through the use of the appropriate tools teachers will be motivated to learn as they will see the possibility of being able to create their own tools to enhance their teaching of the other subjects they present.

2 The Role of Computational Thinking in Learning to Teach Programming

Many involved in trying to get teachers to be able to teach programming have been attracted to the concept of Computational Thinking (CT). This phrase has been made popular by Wing and others [8, 16, 17] but there seems to be a number of potential interpretations of what it is and why it is valuable to learn CT skills even for those who don't see themselves as programmers. [6] has identified five aspects of CT that can be seen as potentially valuable in learning to program but also in tackling other aspects of daily life. He specifies these as algorithmic thinking, decomposition, abstraction, generalisation and evaluation which relate as follows:

- Algorithmic thinking will relate to the choice of approach taken in solving a problem.
- Decomposition involves breaking the problem down into manageable steps.

- Abstraction – involving the removal of the specific problem so that the more generic problem being tackled can be seen.
- Generalising the solutions – using ideas solved before for example as in using sub programs (functions etc.) in a computer program.
- Evaluating – the solutions and the algorithms

One question which suggests itself is how we will know if someone is using CT in their solution to a problem? One might also ask what sort of problems we would use CT for. Also we could ask, “Does CT mean thinking like a programmer or thinking like a computer?” To what extent will we expect people to apply CT in every part of their lives? If teachers for example were able to see the use of CT in their teaching lives, would that improve their motivation to learn to program?

It is useful to think of places where we might expect that CT is clearly valuable. Take the process of entering marks from exam scripts into a spreadsheet. In general the exam papers will have become disordered as the marking process took place. However, the spreadsheet will want the marks to be added in a specific order. We could approach this problem in a purely ad hoc way. We pick up the first paper locate the student ID, scan through the list of IDs in the spreadsheet and add the mark(s). If we have very few papers to grade this process might not take too long. However, if we have a large number of papers we would probably quickly conclude that it would be better to sort the papers first. First of all we are asked to think of this as a sorting problem. This is the process of abstraction. Sorting something with numbers on it that identify the order is a common problem. Thinking like a programmer we would then decide on an algorithm to implement the sorting process. We then need to evaluate the effectiveness of the available algorithms for the task at hand. The level of disorder the papers are in, for example, might influence our approach. If most of the papers are ordered we might choose a simple algorithm, if they are highly disordered we might go for one like the merge sort. Once we have decided to use merge sort we now proceed to think like a computer. We separate the large pile into small piles counting off the number into each pile sequentially. The size we need the piles to be would be chosen based on the number we feel we can easily order. We now act as a programmer again and choose to stop at (say) four as we feel we can now use our human pattern recognition skills to sort these – a programmer thinking choice not a computer thinking choice.

A second example would be choosing a route home using a map. It is probable that we would be inclined to use a satellite navigation system to do this. What we now should do is use the CT concept of evaluation to evaluate the solution given by the software. We are unlikely to get the map and start to plan the process by iterating through the Dijkstra’s algorithm in our heads or on paper. This would have involved us in thinking like a computer and while it is an efficient algorithm for computers to undertake it is only one a human would be tempted to use on very small problems and in such cases a brute force solution might end up being more reliable. Thus in this case it is really the evaluation aspect of CT that is likely to be useful.

A more important concept in the current example is the idea of using a computer program to produce a teaching artefact. In order to produce more sophisticated animations using Flash it becomes necessary to use a number of aspects of CT. Breaking the problem down into manageable parts will definitely be used. Generalisation will also be valuable as many of the tasks we will want the artefact to undertake will be very similar. As the process becomes more sophisticated we begin to get value from actual algorithm design. Our solution can become more efficient as we look at the actual scripts that are produced and we can start to extend machine produced codes to increase the efficiency of what we produce. Thus though some have suggested that Flash is now coming to the end of its life we propose that learning the use of Flash Action Scripting in particular is very valuable for teachers. First it is more intrinsically motivating as the teachers can see the value to them of learning to use the software. Secondly a lot of aspects needed in programming are developed and other software interfaces for producing animations and stories work in a very similar way. Thirdly the teachers can begin to interact with a scripting program that is powerful and works with many of the concepts they will need to learn to teach. Additionally others have pointed out the value of teachers being able to engage with the creation of their own teaching aids [10].

3 Training of Teachers in the Use of Educational Technology Using Flash Action Script

The initial motivation for this research was experience of one of the researchers in teaching at a teacher training institute in Malaysia. This experience showed a great tendency of learners to adopt approaches to learning the use of Flash Action Scripting in one of their classes that did not involve Computational Thinking (CT) but rather using ad hoc solutions to problems being faced. Generally the lessons were prepared in a traditional way with the staff member giving formal lectures backed up by PowerPoint presentations and live demonstration in front of the class. Learners were then given example tasks to undertake for themselves. On the whole instead of understanding the process students were inclined to try to copy and paste from the original lessons and while this might appear to be using the principle of "re-use" without first evaluating the codes they were copying the result would not be what they were aiming at. This leads to frustration in the users and feelings of fear of the whole concept of using a tool. The student teachers were surveyed after their training over their attitudes and it became clear from these initial surveys that the students could see that learning to use Flash Action Scripting would be intrinsically valuable to them. It was thus decided to develop a pilot study in which the possibility of developing an automated teaching tool would be tested. It would be necessary in the study to identify specifically where learners were adopting non CT approaches and how to correct these problems. Once these were identified the automatic tool could be designed to do the same. Utilisation of such an environment builds upon the views expressed by others of the value of using instructional video in e-learning [14, 18].

Hammond [9] mentions the significance of ICT even if engagement is not to be taken for granted and the effect of the learning is complicated. Others have sought to emphasise the need to integrate technology into education. For this to be done successfully it needs to be integrated into the training of the teachers. The arguments around this have been summarised in [13].

4 Experimental Method

For the pilot project two groups were recruited. Though the difference between the groups is not the major focus of this paper one group was of eight experienced teachers and one of eight trainee teachers. No member of either group had previously taken a computing or engineering course where they would have been exposed to training in programming. All of the participants were from Malaysia. The experienced teachers were all in the UK studying for advanced degrees in subjects of value to them. One of these was expecting to return to an administrative role on completion of his studies. The trainee teachers were all on a PGCE course, having completed a variety of first degrees. They were expecting to return to work in schools in Malaysia. The experiment was subject to the ethics approval process and all participants were invited and partook through their own free choice. All gave permission for their responses to be reported but in an anonymised form. They are therefore quoted in an anonymous form. The initial experimental process involved:

- Pre-session interviews to identify attitudes and experience
- A session consisting of a sequence of one on one lessons in the use of Flash Action Scripting and the Flash tool
- A parallel set of example exercises to be undertaken by the participants
- Post –session interviews to identify any changes in perception

In addition to the interviews the participants' performance during the lessons and practice sessions was recorded. Activities were transcribed for analysis and coded. The frequency of the codes found was then analysed. The approach used is based on Grounded Theory and the analysis method is common in that approach.

Charmaz [4] depicts grounded theory activities such as coding as 'grounded theory guidelines'. She indicates that these guidelines can be used in a wide range of studies by researchers who all bring with them their own background, understandings and theoretical framework.

Line by line coding is a category of coding used for the current research. Charmaz recommends that there be at least two primary phases of coding in grounded theory: the preliminary phase where data is assessed by segment or line by line; and the second focused phase where substantial amounts of data are ordered by the most frequently occurring codes (2006).

Turning a code into a classification occurs through analysing an initial code and defining its properties [3]. At this stage the researcher's interests may influence what questions are asked of the data. For instance, as the current researcher has a focus on motivation to learn programming questions specific to obtaining more information about participant's experiences with computing or programming were asked.

Open coding, which is also denoted to as first-level coding, is often expressed using the participants' own words and was an early step in the coding process in this study. Charmaz discusses coding and recommends that the preliminary line by line coding that many grounded theorists engage in allows them to remain connected to the data.

Open coding was first undertaken. Hundreds of line by line codes were identified in the interview data, usually using participants' own words, some which included participant comments such as:

- Not feeling good enough
- Feeling Inferior
- Student engagement
- Everything needs to be creative
- Feeling Scared
- Feeling demotivated
- Difficult to learn
- Too technical
- I am social art students
- Why I should learn programming
- Module prepared by school
- Time consuming
- Low self-confidence

The formal codes reflected the following positive attitudes:

- I - Interest
- E - Engagement
- M - Motivation
- C - Confidence
- En - Enjoyment
- A – Affordance

And the following negatives:

- B - Boredom
- L - Lack of Motivation
- Co - Confusion
- F - Fear
- D – Difficulty

These codes were therefore applied to the transcriptions. Examples of the open coding are included in Table 3 in Sect. 5.4 below. The time taken to develop a level of engagement was also recorded as a separate measure of participant engagement/motivation.

The lessons used in the pilot study are briefly described the next section.

5 Pilot Lessons

The idea of the pilot lessons was to identify where CT thinking was being applied or not being applied by the participants. The aim of this was to identify how to develop an automatic tool that itself could identify failing in thinking and therefore guide the participants in the learning process in order to encourage them to use computational thinking. The content and approach of the pilot lessons was modelled on the approach being used in training teachers in the use of Flash Action Scripting in Malaysia. The lesson first introduced the task that was to be undertaken and then led the participants through the process of developing the example of a teaching artefact for early years learning. Some of the teachers were not teaching in primary school so there was the possibility that this lesson would not motivate them. Similarly not all of the trainee teachers would end up as primary school teachers. It is possible therefore that better results would be obtained with a range of example lessons but this was not practical for the experiment. The details of the lesson have been specified elsewhere [12]. The purpose of the lesson was to show how the Action Scripting language could be used to produce an artefact that might be seen as valuable to the teaching of the participants in future. The lesson involved a sequence of stages of increasing complexity so that computational thinking ideas could be introduced steadily. The first process was to get the participants to understand the working of the interface itself and then how each component is used. To do this the production of a simple menu system formed the first part of the lesson. An example of how to get the first menu button to work was given and in the subsequent exercises the participants were required to add other buttons to the artefact being developed and to add appropriate action responses. At each stage wrong thinking by the participants was identified and corrected and correct thinking was identified and encouraged. The process of the lesson involved a lot of interaction with the researcher acting as tutor and the content of this interaction was vital to the design of the automatic tool that has subsequently been developed. Examples of the screens produced by the artefact being developed are given in the following figures.

The next section details the results that were obtained from the pilot study and we then move on to introduce how the resultant automated tool has been developed and testing of it begun.

5.1 Initial Interviews

As mentioned above a set of pre interviews were undertaken in order to allow for comparison between the pre and post session attitudes to programming and the use of Flash Action Scripts in particular. Certain differences also emerged between the qualified and trainee teachers in this session. Of the established teachers the responses to questions regarding the likely usefulness of learning Action Scripting were negative and all were nervous of the need to use a technical tool. A typical response was "*I am not good in using technology especially programming. I am afraid of using technology actually. I don't like to use computers …*"

The PGCE (trainee) students were less reticent to take part. They all felt it would be good to learn to use Action Scripts as it would enable them to use the tool to make their own teaching/learning instruments. However, they generally did not feel it would be easy to learn as it appeared to involve a similar process to learning more formal programming systems like C ++. A typical quote from this group was "*I want to learn this programming language and I will come out with my own teaching module soon!*" There were some negative attitudes, for example one subject asked "*Why would I need to learn Flash or have to design a learning tool as all of my lesson material will be provided by the school?*"

5.2 Performance in the Practical Sessions

During the practical sessions the volunteers were required to produce code that performed the set of functions shown in Figs. 1 , 2 and 3. The performance was monitored and the actions were recorded using screen capture so they could be analysed afterwards. The major problem was the tendency to copy and paste previous examples rather than to analyse the problem, understand the components that were needed and develop the appropriate set of steps to produce the artefact. When they found their actions had not produced the correct behaviour they were asked to analyse why this had happened. They were taken back to previous steps and the lesson was repeated until they were able to produce the correct output. Different processes in producing a good learning artefact

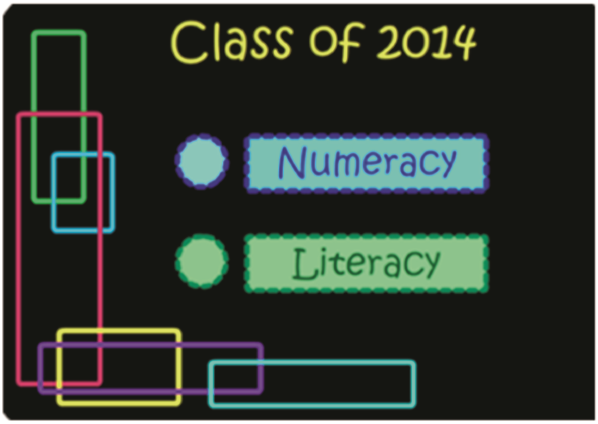

Fig. 1. Original page.

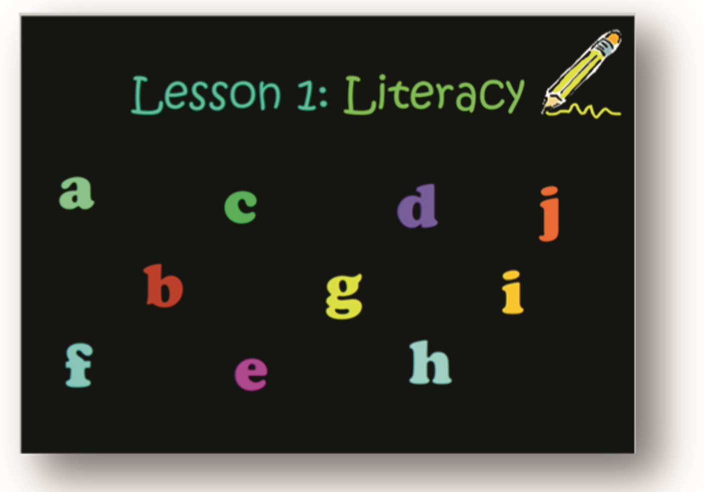

Fig. 2. Literacy screen.

Fig. 3. Scene with added animation path.

were identified against the Computational Thinking approach. A good example is the idea of abstraction as embodied in the concept of a layer.

In Flash Action Scripting the layer is a basic abstract component that gets non abstract components – actual text, pictures, and scripts – attached to it. As a result a user thinking computationally would be expected first to engage with the abstraction – by invoking a new layer for a new action – then to populate it. Thinking non-computationally exhibited itself in various different ways. One typical example was when users wanted to remove an existing layer. Instead of selecting the layer and deleting it the users who were not thinking about the abstraction would delete the contents of the layer rather than the layer. This would lead to an error when the code was compiled and an error message that was not understood by the user. Such error statements alert the teacher with experience to the lack of correct thinking. The user is then directed to the part of the lesson on layer creation.

The PGCE students all grew in confidence and enthusiasm for the process of learning Flash Action Scripting more quickly than the experienced teachers, however, all participants were able to finish the first task correctly. Enthusiasm for and motivation to use the tool were indicated by comments made by the experimental subjects. The trainee teachers generally were more enthusiastic to start with and thus were more motivated to understand and correct their mistakes.

The average time to complete the initial task was 35 min. The longest time taken for the process was one hour and this was from a subject who had shown the lowest motivation for the task as he intended to return to administration within a school and not teaching.

5.3 Post-Session Interviews

After the first practical session the subjects were all re-interviewed. They were asked questions about their attitude to learning Flash Action Scripting having now been exposed to it. Questions centred on their views regarding the potential usefulness of learning to use Flash Action Scripting, technology in general, their motivation and ability to learn Flash Action Scripting and their understanding of the steps used in computational thinking.

Most of the experienced teachers felt an improved attitude towards the usefulness of the process. The teacher who intended to return as an administrator had not improved his attitude at all. One of the others still did not see that it could be useful to them in their teaching or to teaching in general. The other five were enthusiastic about the possibilities. Of the PGCE students all were convinced not only of the value of the tool but also of their ability to learn to use it.

When asked about the use of technology in general to support their teaching the experienced teachers had generally gained an improved attitude.

Most of the experienced teachers did not feel intrinsically motivated to learn programming but had found the process of the lesson enjoyable and felt they had been successful in learning how to use the tool. Eight of the ten trainee teachers expressed the idea that they found the learning intrinsically motivating as they felt they would benefit in their own careers. These have all moved on to the further study of the subsequent lessons and have been willing to try to learn further by themselves!

The CT skills needed in the task to perform it efficiently were those of Algorithmic thinking and Abstraction. Eight of the trainees exhibited Algorithmic thinking by the end of the first lesson and seven had demonstrated use of Abstraction. However, only four of the experienced teachers had developed this CT approach. For example in the use of layers – linked to the concept of abstraction – seven of the trainee teachers and one of the experienced teachers had understood how to properly use layers.

5.4 Thematic Analysis

As was explained in Sect. 4 above, the recordings of the interviews during the practical session were all transcribed and the transcriptions were then thematically coded looking for different indicators, as explained in Sect. 4, relating to positive and negative attitudes. Table 1 below shows themes that emerged prior to the experiment taking place.

As can be seen from the results in Table 1 the trainee teachers demonstrated higher levels of positive attitudes to the potential value of the training they were about to undergo, when compared with the experienced teachers (indicated by a total of 96 coded positive statements by the trainee teacher group and only 61 by the experienced teachers). However both groups had negative attitudes in some of their statements and in particular felt the process of learning Flash Action Scripting would be difficult (roughly equal numbers of negative comments on difficulty) and that they found what they were being asked to do potentially confusing (again with similar numbers of negative comments from both groups). None of the experienced teachers expressed any confidence that they would develop the ability to use the tool but eight comments from the trainee teachers expressed such confidence.

Table 1. Frequency of appearance of code phrases in use by the Trainee Teachers (TT) and the Experienced Teachers (ET) **before** taking part in the experiment.

Codes	TT Frequency	ET Freq.	Total
Interest (I)	23	17	50
Engagement (E)	24	15	39
Motivation (M)	27	15	42
Confidence (C)	8	0	8
Enjoyment (En)	12	11	23
Affordance (A)	2	3	5
Boredom (B)	3	11	14
Lack of Motivation (L)	6	15	21
Confusion (Co)	27	32	59
Fear (F)	15	12	27
Difficulty (D)	32	26	58

Table 2 demonstrates the frequency of code words in the post-experiment interviews and it can be seen that both the trainee and experienced teachers had significant improvements in their attitudes towards learning Flash Action Scripts and programming technology in general. Of particular note is the fact that no phrases emphasising "Fear" (F) were recorded in the post-experiment responses by either group though some "Confusion" (Co) still remained in both groups (a total of 23 such comments roughly equally divided between the groups) and there was still a residual view that the process was "Difficult" (D) though this was much reduced with a total of ten comments expressing difficulty after the experiment compared to the 58 difficulty comments made before the experiment. Only one of the participants (the experienced teacher now moving into administration) used "Boredom" (B) and "Lack of Motivation" (L) phrases – two responses fitting this description for both categories. Together with the increased number of positive comments on motivation (a total of 81 such comments after the experiment compared to 42 before the experiment) this indicates that those who were expecting to be teachers after their courses all believed the use of Flash Action Scripting to be interesting and motivating. There were few phrases mentioning "Confidence" (C) before the experiment- 8 from the trainee teachers and none from the experienced teachers; after the experiment only one of those involved (the administrator) failed to respond with any confidence statement. A total of 42 such comments were recorded from the rest of the subjects.

Table 2. Frequency of appearance of code phrases in use by the Trainee Teachers (TT) and the Experienced Teachers (ET) **after** taking part in the experiment.

Codes	TT Frequency	ET Freq.	Total
I	39	19	58
E	29	24	53
M	54	27	81
C	22	20	42
En	22	19	41
A	12	8	20
B	0	2	2
L	0	2	2
Co	13	10	23
F	0	0	0
D	7	3	10

The time taken to begin to show signs of engagement and enjoyment of the use of Flash was generally lower for the trainee teachers than for the experienced teachers but only one (the administrator) failed to complete the task and failed to become engaged in the process after 20 min.

Examples of quotes reflecting the codes used are listed in Table 3 below. Some of the phrases quoted show more than one of the coded attitudes. They were coded as representing both the trainee and experienced teachers' attitudes but are only shown as illustrating one. All of the comments listed were given by trainee teachers (respondent TT5 means trainee teacher 5) though similar comments were made by the experienced teachers.

Our results demonstrated that use of the tool would increase interest in Flash Action Scripting and enhance enthusiasm for programming with reduced levels of confusion and frustration. The next step has been the development of the tool based on the findings and approach taken in the preliminary experiment.

Table 3. Examples of coded comments given by the Trainee Teachers (TT 4 to TT 10).

Code	Quote
I	"As a first time learner like me, this software is easy to learn and the instruction is quite simple…" (respondent TT5)
E	"Very good! I think students will feel more enthusiastic to learn the subject if the teaching instrument used is interesting" (respondent TT4)
M	"I think it is attractive software to learn and teach also. Besides teachers learn how to program, I think we can teach our students to learn how to program as well" (respondent TT10)
C	"I am looking forward to studying more on this and producing my own lesson…" (respondent TT9)
En	"I knew that Flash can do interesting tasks like interesting courseware to gain students' attention" (respondent TT6)
A	"Can you give me a few minutes to try on my own on this software? I would like to produce a small interactive lesson about our lesson just now. I am just so excited to do animation and navigation buttons" (respondent TT4)
B	It is too hard for me to start learn the new software and need to struggle about the technical terms…." (respondent TT5)
L	"… There is just a waste of time to learn new software, I prefer to get the teaching tools that will be provided…" (respondent TT5)
C	make me feel confuse about technical terms and interface too…" (respondent TT5)
F	"I am afraid I could not produce the module at all because I am not good handling the technical tasks…" (respondent TT5)
D	"… sometimes it very hard to understand especially the complex syntax…" (respondent TT7)

6 Development of the Tool

The tool itself has been developed using Flash Action Scripting. By analysing the results of the experiment above it was possible to identify points at which the participants made errors. The tool is designed around the lesson that was provided in the one-on-one training. This has been split into phases such as:

- Introducing the tool
- Identifying the function of the basic elements (Fig. 4)
- Leading the learner through some phased exercises
- Querying the user on their performance

- Using the data from the first experiment to identify if any mistakes have been made
- Leading learners through corrective lessons based on their performance
- Repeating previous stages with increased complexity

The tool also tries to identify aspects of the training in relation to basic computational thinking components. For example:

- Decomposition involved in breaking the problem down [6], usually in a forward direction, identifying major tasks that move the solution to the objective.
- Staged worked examples which are implemented by giving students partially completed code and asking them to complete it correctly. This is done in the development environment to provide feedback.
- Encouraging the learners to write pseudocode to solve a problem is a computational thinking skill; translating that pseudocode into Action Script is a programming skill (Fig. 5).

Examples of screen shots from the tool are given below:

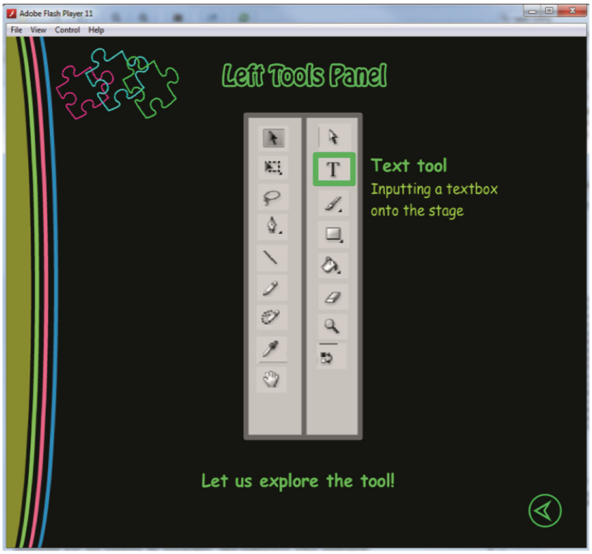

Fig. 4. An example of a training stage introducing the formatting tools.

The next section provides some early results from testing the automated tool.

7 Initial Testing of the Automated Learning Tool

A similar set of participants was recruited for the initial testing of the tool. Eight trainee teachers were chosen. Each of these had a similar background to the first group. Pre-trial interviews were once more undertaken and similar responses to the thought of learning to program and to Action Scripting were again found. One issue was that the tool was designed to be used by the participants in their own time as well as while being observed by a researcher. This produced an interesting response from one of the new participants:

> "… I think this is an interesting programming language to be learned with the proper guidance from the tutor or instructor…"

A second participant responded:

> "What if I face the problems over the weekend?"

This exchange showed their fear, perhaps, of the automated teaching tool. However, these fears proved unfounded and having had a preliminary observed use of the tool; the participants all found it easy to use. Comments by the same two participants after use of the tool included:

> *"… I can now do my own programming without any helps!"*
> "This is really a great tool! I can work with it anytime, anywhere…"

The most encouraging feedback was received from one of the participants:

> "This is like online manual and at the same time module that really give a big impact for me as a trainee teacher, to develop my own teaching module soon!"

And finally from the participant who expressed fear of working at home on their own:

> "Can I get a copy of this tool?"

Further more formal analysis of the results has yet to be completed but these initial responses indicate that the tool will be at least as effective as one on one lesson (Fig. 5).

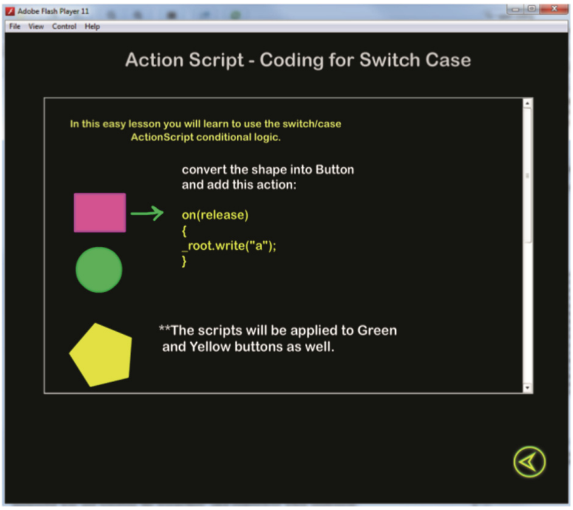

Fig. 5. Looking at producing scripts using generalisation through switch cases.

8 Conclusions

In the introduction we highlighted that the need for more programmers is now urgent. Software companies and governments around the world have become convinced that a change in the way technology is taught in schools is needed. It is felt vital that children begin to learn to program and more importantly think like programmers. The concept of Computational Thinking (CT) has recently developed and the role that this plays in developing the correct thinking to be a programmer is clear. In the introduction we also highlighted the need there will be to train elementary school teachers to be able to teach programming. It is not expected that these teachers will themselves become programmers. Also as was explained in the introduction ways of getting them to learn to program that are effective with children will not be effective with them as on the whole they will be less attracted to the idea of being able to develop their own simple games. Through our experiments we have shown that teachers who are not initially secure with the idea of learning to program can be motivated to learn by using a tool that they can see has intrinsic value to them. The tool we have begun to develop is based around teaching the use of the Flash animation tools and the production of Flash Action Scripts. Our experiments with trainee and experienced teachers have identified that this is true and those who were involved in our pilot study of one-on-one lessons increased both in their confidence to use the tool and their CT skills. It is thus believed that having undergone such training they will be less apprehensive of the material they have to deliver to the children they teach. Using the results of the observations of the participants during their learning it has been possible to begin to produce an automated tool that guides learners through the process. In the pilot study we identified ways in which wrong thinking or non-CT were hindering the learning of the use of Flash Action Scripting. In the automated tool ways of identifying why wrong actions have been undertaken have been introduced. Repeating lessons about the specific subjects of need or giving special instruction when a cause of wrong thinking has been identified has allowed the unsupervised learning to continue using the tool. An initial experiment with the tool has shown it to be effective in teaching the use of Flash Action Script, improving learner confidence in their ability to use technology and improving their Computation Thinking. The tool will now be refined as a result of the testing and further improvements are expected.

References

1. Begosso, L.C., Begosso, L.R., Gonçalves, E.M. Gonçalves, J.R.: An approach for teaching algorithms and computer programming using Greenfoot and Python. In: Frontiers in Education Conference Proceedings, pp. 1–6. IEEE (2012)
2. Bogdanchikov, B., Zhaparov, M., Suliyev, R.: Python to learn programming. J. Phys. Conf. Ser. **423**, 012027 (2013)
3. Charmaz, K.: 'Discovering' chronic illness: using grounded theory. Soc. Sci. Med. **30**(11), 1161–1172 (1990)
4. Charmaz, K.: Constructing grounded theory: a practical guide through qualitative analysis. Sage Publications, Thousad Oaks (2006)

5. Crick, T., Sentance, S.: Computing at school: stimulating computing education in the UK. In: International Conference on Computing Education, pp. 122–123 (2011). http://dl.acm.org/citation.cfm?id=2094158
6. Dorland, M.: Developing creativity and computational thinking in your computing classroom. In: CAS Meeting Birmingham United Kingdom, September 2014
7. Franklin, D., Conrad, P., Boe, B., Nilsen, K., Hill, C., Len, M., Dreschler, G., Aldana, G.: Assessment of computer science learning in a scratch-based outreach program. In: Proceedings of the 44th SIGCSE Technical Symposium on Computer Science Education, SIGCSE 2013. ACM (2013)
8. Grover, S., Pea, R.: Computational Thinking in K-12: A Review of the State of the Field. Educ. Res. **42**(1), 38–43 (2013)
9. Hammond, M.: Introducing ICT in schools in England: rationale and consequences. Br. J. Educ. Technol. **45**, 191–201 (2013)
10. Lin, C.H.: An innovative change in technology integration: training pre-service kindergarten teachers to be courseware designers. Creative Educ. **03**(07), 1177–1183 (2012)
11. Meerbaum-Salant, O., Armoni, M., Ben-Ari, M.M.: Learning computer science concepts with scratch. In: ICER 2010: Workshop on Computing Education Research, pp. 69–76 (2010)
12. Saari, E.M., Blanchfield, P., Hopkins, G.: Learning computational thinking through the use of flash action scripts – preparing trainee elementary school teachers for teaching computer programming. In: Proceedings of the 7th International Conference Computer Supported Education (CSEDU), Lisbon, Portugal, pp. 75–84 (2015)
13. Tondeur, J., Van Braak, J., Sang, J., Voogt, J., Fisser, P., Ottenbreit-Leftwich, A.: Preparing pre service teachers to integrate technology in education: a synthesis of qualitative evidence. Comput. Educ. **59**(1), 134–144 (2012)
14. Wieling, M.B., Hofman, W.H.A.: The impact of on-line video lecture recordings and automated feedback on student performance. Comput. Educ. **54**(4), 992–998 (2010)
15. Williams, P.: Independent review report of mathematics teaching in early years settings and primary schools (2008). http://dera.ioe.ac.uk/8365/1/Williams%20Mathematics.pdf. Accessed 21 October 2014
16. Wing, J. M.: Computational Thinking CS @ CMU and Grand Vision for the Field (2006)
17. Wing, J.M.: Computational thinking and thinking about computing. In. Philos. Trans. Series A, Math. Phys. Eng. Sci. **366**(1881), 3717–3725 (2008). doi:10.1098/rsta.2008.0118
18. Zhang, D., Zhou, L., Briggs, R.O., Nunamaker, J.F.: Instructional video in e-learning: assessing the impact of interactive video on learning effectiveness. Inf. Manage. **43**(1), 15–27 (2006)

Analyzing the Academic Approaches to Learning of Portuguese College Students Through the Psychometric Study of a Questionnaire

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Abstract. Background: Assessing the college students' more often utilized approaches to learning, as they are understood by Biggs and his collaborators could be paramount to infer the way students learn. Such knowledge can be fundamental for the academic community, particularly when considering that the option for a deep approach to learning as opposed to a surface approach is often considered connected to a more significant learning. Aim: The present study focused on the adaptation and validation of the Revised Two Factor Study Process Questionnaire (R-SPQ-2F) [1] for the Portuguese college student population. Method: This study involved the participation of 241 male and 466 female college students and internet users, whose ages ranged between 18 and 40 years old (M = 22.96; SD = 4.41).

To be included in this research the participants had to: (1) be Portuguese and study in a Portuguese college institution, and (2) be willing to participate after learning the research objectives. Participants were recruited through direct contact with college institutions in Portugal and through informal social networks. Additionally the eligible internet users who agreed to participate were asked to refer their friends to participate in the study.

Besides the Revised Two Factor Study Process Questionnaire (R-SPQ-2F) [1], a socio-demographic questionnaire was able used to enable the characterization of the participants' age, gender, degree and University/college attendance;

Results: The Portuguese version of the Revised Two Factor Study Process Questionnaire, unlike the original version which had 20 items only has 16 items. Furthermore, the factor analysis with varimax orthogonal rotation revealed a two factor structure, consistent with other researches of the instrument, but unlike the original's four factor structure. In the Portuguese version found in this study, factor I (deep approach to learning) has a 9 items scope, and includes deep motives and deep strategies (α = .783); factor II (surface approach to learning) has a 7 items scope and includes surface motives and surface strategies (α = .751). Besides the validation of the questionnaire for the Portuguese learning, this research also focused in the separate analysis of deep and surface approaches, namely in what distinguished them in terms of age, gender and academic degree, and it was found that in all cases a significant statistical

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difference was found. This study help conclude that the Portuguese Revised Study Processes Questionnaire is an acceptable measure of the college student's learning approaches.

Keywords: Learning approaches · Study processes questionnaire · Psychometric study

1 Background

The adequacy of the learning techniques used by a teacher and it the act of teaching itself, is according to authors such as [3] dependent upon what each intervenient in the learning process may feel is more suitable. This being accepted, it is easily concluded that the acquisition of knowledge isn't bereft of subjectivism and that no single formula used for teaching and learning will invariably end in academic success. Therefore, assuming that both teacher and student should be responsible for the student's behaviour gains, it comes as no surprise that it is of the most importance to research what will suit different types of students.

For authors such as [4] approaches to learning are a direct characterization of the learning process used by students, most often grouped into categories, which [5] distinguishes between the students that study in order to develop their skill, and those that do it to be able to pass the year or finish a certain academic task. These two categories are respectively, classified by [6, 7] as deep learning and surface learning.

For [1, 8] it is important to point out that just because a student may prefer a deep or a surface approach to learning, that shouldn't be used to classify that student as a deep learning student or a surface learning student. In fact, [9] thinks that even though students' approaches to learning vary and aren't a stable trait of an individual, the knowledge of this preferences might, as pointed out by [10], help the teacher/tutor to search and create study materials appropriate for each and every student.

Even though both types of approach have advantages and disadvantages, depending on the task required, various authors suggest that the adoption of a deep approach to learning might positively influence academic results, because it leads to a more meaningful learning [11] because among other things it will help them in developing ways of promoting the adoption of that approach in the cases where they aren't using it already. It should be noted that this doesn't mean that memorization and other surface approach techniques might not be adequate when performing certain tasks, including evaluation [12].

In relation with the materials used to evaluate learning conceptions and approaches to learning, [13] indicates that there are few that have been normalized and validated for Portuguese college students. The decision to use the R-SPQ-2F [1] derives from the fact that this instrument was created to: (1) identify the learning approaches preferred by students, indicating how much a student differs from his peers in a similar context; (2) ask students to fill a questionnaire with questions adapted to a certain task, which indicate how students actually perform the task; (3) indicate the context evaluation, providing information regarding differences between classes or teaching environment.

Furthermore, the authors of this questionnaire believe it can be used in different classes, institutions, and grade system before and after introducing changes. On a last note, the R-SPQ-2F has been used all over the world, adapted when necessary, which renders it a natural good choice.

2 Aim

The scale used for the Portuguese college student population, while at the same time producing comparative measurements of participants' gender, age, type of superior education institution of enrolment (university or polytechnic institute), degree of enrolment (graduate, masters, PhD) and year of graduation participants are attending. Various variables were studied: variables inherent to the questionnaire, total scores and scores attributed to the questionnaires dimensions. It was considered that gender, age, degree and year of enrolment are independent variables and students study processes (deep and surface approach) are dependent variables.

3 Method

3.1 Material

Socio-Demographic Questionnaire. A socio-demographic questionnaire was built for the study. In it the questions aimed to characterize participants in terms of age, gender, academic degree, year of the respective degree the participants were enrolled at during the elective year 2013–2014, type of establishment the participants were attending (university or polytechnic institute) and the identity of the referred establishment.

Two Factor Revised Study Processes Questionnaire (R-Spq-2f) [1]. The R-SPQ-2F is composed of 20 items that evaluate the approaches to learning, grouping them into two dimensions, with 10 items evaluating deep approach and 10 items evaluating surface approach. Each scale has two subscales measuring motivation and strategy components. This means the subscale that measures deep learning is composed of 5 deep motive items and 5 deep strategies items, while the subscale that measures surface approach has 5 items relating to surface motives and 5 items relating to surface strategies. All items are classified in a 5 options Likert scale, between 1 (never or rarely true) and 5 (always or almost always true).

The total score in each scale is calculated by the sum of the score obtained in the items relating to it, that is, for the Deep Learning scale, the sum is comprised of items 1+2+5+6+9+10+13+14+17+18 and for the Surface Learning scale, the sum is comprised of 3+4+7+8+11+12+15+16+19+20. To calculate each subscale the sum of the corresponding items is made: Deep motive: 1+5+9+13+17; Deep strategy: 2+6+10+14+18; Surface motive: 3+7+11+15+19 and surface strategy: 4+8+12+16+20. For each scale the score varies between 10 and 50 and for each subscale between 5 and 25 [1].

In this research, between the various models to score the questionnaire's items found in the literature, the one used by [14] was chosen. In it the higher the medium score, the more a type of approach is being used.

Because there have been many adaptations of the R-SPQ-2F, in different languages, the results of those psychometric studies vary. The Cronbach's alpha varies between .57 in [1] and .78 in [15] in the surface strategy subscale, for example, and other such differences can be found for the other 3 subscales. Additionally not all adaptations found the proposed two scales and 4 subscales structure found in the original questionnaire [1]. In fact, some studies suggest solely the presence of two factors, namely the two approaches to learning (deep and surface) [16–18], even after performing a second or third order factorial analysis.

On a last note it should be added that the two types of approaches to learning reflect both the student's intention towards learning and the strategies the student uses to reach that knowledge.

3.2 Procedure

Previously to the development of this research a literature review helped choose the learning concept to be measured and studied. Following the choice of variable, a review of the known instruments to measure it was undertaken. Additionally it should be noted that permission was asked and granted by the author of the original instrument [1] for it to be validated and used in a sample of Portuguese college students.

It was necessary to translate the original instrument from English to Portuguese. The Portuguese version results from a formal process of linguistic adaptation, with translation and retroversion by specialists in the English language and in Psychology. The specialists targeted the creation of a version equivalent with the original, both from a linguistic structure as from a semantic content stand point.

After finishing this step, the formal data collection was initiated with a pilot study that used six participants, and aimed to guarantee that both the instructions and the questions or items in the instrument were clear. It was necessary to do some small alterations to account for the observations made in the pilot study.

The instrument was made available using Google forms and a link for the questionnaire was distributed by email, Facebook, and personal contact list, to the Portuguese college institutions and students. Additionally word of mouth was also used to spread the request for filling the research form.

During all the process anonymity and confidentiality were guaranteed to all participants and the instructions held an e-mail to handle all possible questions and doubts.

Reception of answers to the questionnaire was available during January 2014. The answers stored in the online database provided with Google forms was afterwards transferred to Excel (.xls) for initial analysis and then migrated to SPSS v.22.0 for further and more complete analysis.

4 Results

In order to make sure that the Portuguese version of the revised study processes questionnaire could be used in the future by other researchers in other studies, the instrument was analysed in terms of it sensibility and reliability and factorial analysis.

4.1 Sensibility

The sensibility analysis of the items was done through measurements of Skewness and Kurtosis. According to [19], I2I absolute values indicate absence of dispersion which guarantees an instrument sensibility. All items showed a good sensibility with the exception of item 7, which was for this reason eliminated. In Table 1 items and corresponding sensibility values are presented.

After analysing sensibility, internal consistence was also analysed.

4.2 Reliability

The internal consistency of the R-SPQ-2F (without item 7), given by the Cronbach's alpha was unacceptable as a value of .484 was obtained. After further analysing the alpha values it was concluded that if item 4 was eliminated an alpha of .511 was produced, coinciding with a weak internal consistency.

An exploratory factor analysis was performed; that is, without previous fixed dimensions items were allowed to group and form dimensions. Afterwards sample adequacy was tested through the Keiser Meyer Olkin (KMO) test. This test whose scores vary between 0 and 1, considers that scores close to 1 are evidence of an excellent adequacy [20]. For this instrument a KMO = .857 was obtained. Furthermore, Bartlett's test revealed an X2 = 2897.626; $p < .001$, indicative of the adequacy of performing the factor analysis. The principal components method was applied to extract factors and varimax rotation was used to arrive at the factor solution.

Initially four factors were produced, with a total explained variance of 49.991 %. Factor 1 is comprised by 7 items relating to deep motives and strategies and explains a total variance of 17.378 %, with an alpha of .779; factor 2 is formed by 5 items related to surface motives and strategies, and explains a total variance of 13.224 %, with an alpha of .703; factor 3 has 3 items related to surface motives and strategies and explains a total variance of 11.117 %; finally, factor 4 has 3 items related to deep motives and strategies and explains a total variance of 8.271 %, with an alpha of .449, which justifies the elimination of this dimension and, consequently, of items 2, 17 e 18, even though according to authors as [21] the alpha score should be at least .40 to be considered acceptable. Table 2 shows the organization of the extracted factor analysis dimensions and the factor scores for the items. By observing Table 2, it is possible to conclude that the factor structure found in the theoretical design of the instrument proposed by [1]: 4 subscales resulting in 4 different factors, isn't verified in the present study.

Table 1. Skewness and Kurtosis values of the Portuguese version of the items of the revised study processes questionnaire [1].

Items	Skewness	Skewness std. error	Kurtosis	Kurtosis std. error
1. Studying gives me a sense of…	−.196	.092	−.470	.184
2. I have to work or study hard…	−.161	.092	−.609	.184
3. My objective is to pass the year…	1.007	.092	.310	.184
4. I only study seriously what is given…	−.413	.092	−.502	.184
5. I feel that every subject might…	−.305	.092	−.403	.184
6. I consider the majority of new…	.154	.092	−.469	.184
7. I don't think my course is very…	1.996	.092	4.107	.184
8. I learn some things by heart…	.666	.092	−.091	.184
9. I consider that studying academic…	−.269	.092	−.549	.184
10. I ask myself questions…	−.485	.092	−.192	.184
11. I believe I can obtain approval in…	.578	.092	−.237	.184
12. Generally, I just study…	.213	.092	−.528	.184
13. I study hard because…	−.148	.092	−.387	.184
14. I spent a fair amount of my…	.584	.092	.044	.184
15. I don't consider it is useful to study…	.934	.092	.648	.184
16. I consider teachers don't…	.088	.092	−.867	.184
17. I go to the majority of classes with…	.389	.092	−.428	.184
18. I make it a point of looking at…	−.205	.092	−.681	.184
19. I don't see any reason in…	.508	.092	−.213	.184
20. I believe the best way to pass…	.876	.092	.312	.184

Afterwards, the Scree Plot was analysed and the pronounced curvature considered consistent with a two factors solution. Based on this information a new factor analysis with varimax rotation was performed, locking two factors.

Fixing the two factors, the explained total variance of the instrument becomes 37.008 %, and the instrument is now composed of 2 factors. Factor 1 has 9 items

Table 2. Component matrix by principal component analysis, and items factor value.

Items	Factors			
	I	II	III	IV
9. I consider that studying academic…	.721			
6. I consider the majority of new…	.719			
14. I spent a fair amount of my…	.707			
13. I study hard because…	.644			
1. Studying gives me a sense of…	.610			
10. I ask myself questions…	.486			
5. I feel that every subject might…	.430			
16. I consider teachers don't…		.727		
19. I don't see any reason in…		.676		
15. I don't consider it is useful to study…		.624		
12. Generally, I just study…		.598		
4. I only study seriously what is given…		.578		
3. My objective is to pass the year…		.495		
11. I believe I can obtain approval in…			.805	
8. I learn some things by heart…			.796	
20. I believe the best way to pass…			.708	
18. I make it a point of looking at…				.657
2. I have to work or study hard…				.605
17. I go to the majority of classes with…				.422
α	.779	.736	.717	.449

related to deep approach, including deep motives and strategies and is denominated "Deep Approach". This factor explains a variance of 20.463 %, and has an alpha of .783; factor 2 is composed by 7 items, including surface motives and strategies, and is denominated "Surface Approach". This factor explains a variance of 16.544 % and presents a .751 alpha, as shown in Table 3.

The Portuguese Revised Study Processes Questionnaire (QPER) presents a two scales factor structure and not the 4 subscales presented in the original instrument [1]. Furthermore, the Portuguese questionnaire is composed of 16 items and not the 20 items of the original.

The structure and total score calculus proceedings for each approach result of the total score of the sum of the items in each respective dimension as shown in Table 4.

Besides validating the instrument, the data collected in this research was further analyzed to study its compliancy with proposed hypothesis on whether gender, age and degree of scholarship might produce statistical significant differences in one or both of the scales.

The research found that there is a significant statistical difference between genders (see Table 5). In terms of Surface Approach male students (M = 16.73; SD = 4.38) have higher scores than female students (M = 15.45; SD = 4.26), with a statistical significant difference of $p < .001$. When analysing Deep Approach, results showed than female students (M = 28.03; SD = 5.34) have higher scores than male students (M = 26.75;

Table 3. Organization of the factor analysis extracted dimensions, fixing two factors and presenting the factor score values for each item.

Items	I	II
1. Studying gives me a sense of…	.656	
5. I feel that every subject might…	.437	
6. I consider the majority of new…	.627	
9. I consider that studying academic…	.666	
10. I ask myself questions…	.532	
13. I study hard because…	.694	
14. I spent a fair amount of my…	.674	
17. I go to the majority of classes with…	.487	
18. I make it a point of looking at…	.462	
8. I learn some things by heart…		.661
11. I believe I can obtain approval in……		.712
12. Generally, I just study…		.578
15. I don't consider it is useful to study…		.542
16. I consider teachers don't…		.482
19. I don't see any reason in…		.571
20. I believe the best way to pass…		.734
α	.783	.751

Table 4. Portuguese Revised Study Processes Questionnaire (QPER) final structure.

Dimensions	Items
Deep Approach	1, 5, 6, 9, 10, 13, 14, 17, 18
Surface Approach	8, 11, 12, 15, 16, 19, 20

SD = 4.91), and there is also a significant statistical difference between genders. To both genders higher scores were obtained in the Deep Approach dimension.

When age was analyzed, a significant statistical difference was found between students with ages between 23 and 40 years old and deemed older students (M = 28.56; SD = 5.07) and students with ages between 18 and 22 years old and deemed younger students (M = 26.91; SD = 5.24), and older students scoring higher in the Deep Approach dimension ($p < .001$). In terms of the Surface Approach dimension, a significant statistical difference was also found ($p < .05$), but in this case younger students (M = 16.20; SD = 4.30) scored higher than older students (M = 15.45; SD = 4.36). Concerning age, both younger and older students obtained higher scores in the Deep Approach dimension.

Significant statistical differences were also found between students with a higher degree and a lower degree. In this case, for the Surface Approach dimension, students with a higher degree (M = 15.53; SD = 4.17) scored lower than students with a lower degree (M = 16.19; SD = 4.47) and the statistical significant difference is $p < .05$). As for the Deep Approach, in this case students with a higher degree (M = 28.08;

SD = 5.09) scored higher than students with a lower degree (M = 27.17; SD = 5.31), and there's also a significant statistical difference ($p < .05$). Lastly, in what concerns students with a higher or a lower degree, students scored higher in the Deep Approach dimension.

5 Conclusions

According to authors such as [22–24] the need to promote an educational context that facilitates the students' learning process requires a precise diagnostic of the individual types and approaches to learning these students use. This diagnostics is possible by using available instruments that study the approaches to learning adopted by students when they're faced with different academic tasks and how to adapt the teaching method and techniques in response to those findings.

In this research a particular instrument [1] whose characteristics and objectives were in line with the researchers study was selected, more so because this instrument has been adapted by several researchers.

The R-SPQ-2F evidences a good reliability and sensitivity. In the process of adapting and validating the original instrument, the results of the Portuguese Revised Study Processes Questionnaire were found to not replicate the factor structure found on the original instrument, however they were similar to those found by other researchers when validating and adapting the original instrument to their own samples. The researchers concluded that the Portuguese version of the instrument showed good psychometric properties that make it suitable to apply in studies using samples of Portuguese college students.

Besides enabling the production of a validated instrument, by analysing the data collected the researchers acquired valuable knowledge related not only to what approach to learning is more often used, but also how variables like gender, age and academic degree might influence student choices. Knowing the choices made by students and how those are influenced can allow teachers and tutors to analyse how the techniques and methods they are employing are influencing students in their choices of approaches to learning, and also help teachers and tutors develop ways to adapt their techniques and methods in the hopes of providing a learning environment that promotes the predominant use of a deep approach to learning and therefore make sure students have a more meaningful learning, which authors associate with the predominant use of a deep approach to learning.

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References

1. Biggs, J.B., Kember, D., Leung, D.Y.P.: The revised two factor study process questionnaire: R-SPQ-2F. Br. J. Educ. Psychol. **71**, 133–149 (2001)
2. Biggs, J.B.: The role of metalearning in study processes. Br. J. Educ. Psychol. **55**(3), 185–212 (1985)
3. Biggs, J.: What the student does: teaching for enhanced learning. High. Educ. Res. Dev. **18**(1), 55 (1999). Routledge
4. Kember, D., Charlesworth, M., Davies, H., McKay, J., Stott, V.: Evaluating the effectiveness of educational innovations: using the study process questionnaire to show that meaningful learning occurs. Stud. Educ. Eval. **23**(2), 141–157 (1994)
5. Biggs, J.: Individual differences in study processes and the quality of learning outcomes. High. Educ. **8**, 381–394 (1979). Springer Magazine. Elsevier scientific publishing company. Amsterdam
6. Marton, F., Saljö, R.: On qualitative differences in learning: I - outcome and process. Br. J. Psychol. **46**(4), 4–11 (1976)
7. Marton, F., Saljö, R.: On qualitative differences in learning: II - outcome as a function of the learners conception of the task. Br. J. Psychol. **46**(4), 115–127 (1976)
8. Hamm, S., Robertson, I.: Preferences for deep-surface learning: a vocational education case study using a multimedia assessment activity. Australas. J. Educ. Technol. **26**(7), 951–965 (2010)
9. Biggs, J.: Teaching for quality learning at university. Society for Research into Higher Education and Open University Press, Buckingham (1999)
10. Alharbi, A., Paul, D., Henskens, F., Hannaford, M.: An investigation into the learning styles and self- regulated learning strategies for computer science students. In: Proceedings of ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference, pp. 36–46 (2011)
11. Gomes, C.M.A.: Abordagem profunda e abordagem superficial à aprendizagem: diferentes perspectivas do rendimento escolar. Psicologia: reflexão e crítica **24**(3), 479–488 (2011)
12. Figueiredo, F.J.C.: Como ajudar os alunos a estudar e a pensar?: Auto-regulação da aprendizagem. Educação, Ciência e Tecnologia, RE, 34, Ed. Instituto Politécnico de Viseu, Abril, pp. 233–258 (2008)
13. Valadas, S.T., Gonçalves, F.R., Faísca, L.: Estudo de tradução, adaptação e validação do ASSIST numa amostra de estudantes universitários portugueses. Revista Portuguesa de Educação **22**(2), 191–217 (2009)
14. Hernández, P.F., Sanz, M.P.G., Martínez, P.C., Hervás, R.M.A., Maquilón, J.S.: Consistencia entre motivos y estrategias de aprendizaje en estudantes universitários. Revista de Investigación Educativa **20**(2), 487–510 (2002)
15. Leung, M.-T., Chan, K.-W.: Construct validity and psychometric properties of the revised two- factor study process questionnaire (R-SPQ-2F) in the Hong Kong context. Melbourne Australian Association for Research in Education. Paper presented at the AARE 2001 conference, 2–6 December, 2001 at the Notre Dame University, Perth, Australia (2001). http://www.aare.edu.au/01pap/cha01708.htm. Consultado a 30 July 2014
16. Gargallo, B., Garfella, P.R., Pérez, C.: Enfoques de aprendizaje y rendimento académico en estudiantes universitarios. Bordón. Revista de Pedagogía **58**(3), 45–57 (2006)
17. Phan, H.P.: Examination of student learning approaches, reflective thinking, and epistemological beliefs: a latent variables approach. J. Res. Educ. Psychol. **10**(4(3)), 577–610 (2006)

18. Phan, H.P., Deo, B.: Revisiting the South Pacific approaches to learning: a confirmatory factor analysis study. High. Educ. Res. Dev. **27**(4), 371–383 (2008)
19. DeVellis, R.F.: Scale development: theory and applications. J. Educ. Meas. **31**(1), 79–82 (1991). Spring, 1994
20. Marôco, J.: Análise Estatística com o SPSS Statistics 5ª edição (2011)
21. Ford, J.K., MacCallum, R.C., Tait, M.: The application of exploratory factor analysis in applied psychology: a critical review and analysis. Pers. Psychol. **39**(2), 291–314 (1986)
22. Lublin, J.: Deep, surface and strategic approaches to learning. Centre for Teaching and Learning - Good Practice in Teaching and Learning, Dublin (2003)
23. Pashler, H., McDaniel, M., Rohrer, D., Bjork, R.: Learning styles: concepts and evidence. Psychological science in the public interest. J. Assoc. Psychol. Sci. **9**(3), 106–116 (2008)
24. de Souza, R.B. de L., de Souza, L.N.: Um mergulho nos aspectos da aprendizagem profunda nos cursos de ciências contábeis do brasil. Revista de negócios – Business review 9, March 2010

Adapting Learning Paths in Serious Games: An Approach Based on Teachers' Requirements

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Abstract. Adapting Learning Paths in Serious Games (SGs) is a challenging problem. Indeed, learners are not alike; they have different range of abilities, competences, needs and interests. A well-fitting approach to create adaptive SGs is based on Competence-based Knowledge Space Theory (CbKST). CbKST allows sequencing the SG activities according to knowledge and competences of a domain model, and adaptation is based on suggesting activities that improve learners' competences. However, differences among learners and the diversity of learning situations may drive teachers to consider implementing different adaptive approaches that fulfil their needs.

In this work, we propose to use CbKST to enhance adaptation in SGs by considering not only the learner's competence states but also teachers' decisions based on their needs. More specifically, we have identified different needs concerning the possibility of advancing forward learning paths of SGs, as well as of reinforcing and deepening learners' comprehension in specific subsets of competences. Therefore, we propose different recommendation strategies that allow teachers to modify the behaviour of adaptation in SGs, and we describe how we implemented and evaluated these strategies.

Keywords: Serious Games · Adaptation · Teacher's strategies · Competence-based Knowledge Space Theory

1 Introduction

Adaptation is considered a key issue in Technology-Enhanced Learning (TEL) since learners are not alike; they have different knowledge and skills, as well as learning preferences, interests and attitudes. The motivation for employing adaptive assessment is that learners come to new learning tasks aligned with their profiles [1]. Taking full advantage of such assessments requires the use of adaptive techniques that yield information about the student's learning process and outcomes.

In Serious Games (SGs), adaptation is based on decisions that suggest activities in such a way that the learner is neither unchallenged nor overwhelmed by

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the complexity of the contained tasks [2]. As a consequence, learners become less frustrated and their motivation is increased [3].

Competence-based Knowledge Space Theory (CbKST) has been proven to be a well-fitting basis for realizing adaptation in SGs [4]. This methodology allows a non-invasive assessment of the learner without interrupting the game flow experience [5]. CbKST allows modelling a knowledge domain as a formal structure of admissible and meaningful competence states on the basis of precedence relations among the competences. In other words, CbKST formally structures the activities of an SG with respect to knowledge and competences [5,6]. The SG activities are related to the competences worked on. Learners have to demonstrate that they master these competences by performing the tasks contained in the different SG activities. To this end, systems compute confidence values, linked to learner's competences that represent learners' proficiency level. These confidence values are used as main parameters in the adaptation rules.

In this work, we propose to also consider teachers' decisions as a key factor for adapting SGs in order to address specific pedagogical needs. Learners have different range of abilities, needs and interests, and teachers may consider implementing different approaches that fulfil their needs [1,7,8]. In other words, teachers' decisions could be based on the variety of teaching styles, learners' knowledge and performance, learning styles, and learning contexts [1,9].

Therefore, we propose to enhance adaptation in SGs by considering not only the learner's competence states but also teachers' decisions based on their needs. More specifically, we have identified different teachers' needs concerning the possibility of allowing their students' to advance forward learning paths of SGs, as well as to reinforce and deepen specific subsets of competences. Therefore, in this paper, we propose different recommendation strategies and we describe how we implemented these strategies by using CbKST.

The remainder of the paper is structured as follows. In Sect. 2 we introduce the context of this work, describing the identified teachers' needs for adapting SGs. We also describe the basis of this work that relies on Competence-based Knowledge Space Theory. In Sect. 3, we present the general architecture of the decision module. Particularly, we present the recommendation strategies considering the identified needs presented in the previous section. In Sect. 4, we describe the evaluation that has been carried out in order to compare between the system's results and the results obtained from teachers. Finally, in Sect. 5, we conclude with a discussion of the proposed approaches, as well as future research directions.

2 Context

2.1 Teachers' Needs in Adaptive SGs

This work is framed in the Play Serious Project [10]. The purpose of the project is to develop tools that facilitate the design and development of SGs in the field of adult vocational training. The proposed tools are classified into three different categories:

- Authoring tools for supporting the development of SGs (e.g. SG scenarios).
- Monitoring tools for analyzing learning actions and assessing learners' competences.
- Adaptive tools for modifying learning paths of SGs.

This paper particularly focuses on advancing forward the development of adaptive approaches for serious games (3rd category of tools). In this context, different strategies for adapting SGs have been identified from the joint work with pedagogical experts and teachers involved in the project. Teachers and pedagogical experts from different companies (e.g. sales market) express their needs to deploy some pedagogical strategies. The identified requirements and proposed strategies are described as follows:

The first requirement is related to allow learners progressing autonomously and gradually to achieve all competences of a knowledge domain. The competences have to be worked on at the end of the training session. To meet this requirement, we define the "Advancing" strategy. This strategy considers the learner's proficiency level and proposes activities that work on the maximum number of competences. At each step the proficiency level is updated allowing a progression in the learning path until all competences have been worked.

The second requirement focuses on training sessions that are divided into stages. Given a stage, teachers aim to specify a subset of competences to work on, as well as the degree of achievement as prerequisites to let their learners move forward in the following stages. For instance, in the step "common ground" in sales training, competences that have to be worked on to move forward in the following stage include "identifying customer needs", "collecting information about the customer". To meet this requirement, we define the "Reinforcing" strategy. This strategy allows the learner to reinforce specific competences that have not met a minimum threshold. This case arises when these competences are needed/required in the next stage of the training course.

The third requirement is to offer teachers with the possibility to choose specific competences to let the learners to progress to a higher advanced competence level. Teachers aim to identify learners that are very good in specific competences. The teachers' intention is to lead these learners achieve a very high level in those competences to become quickly operational within the company. For instance, in sales enterprises, trainers could seek for employees that are outstanding in "treating customer objections" or "arguing different solutions to meet the client's needs" in order to become managers of sales team. To meet this requirement, we propose the "Deepening" strategy. This strategy allows learners to become expert in certain competences that they have already mastered within a knowledge domain. One competence has been mastered when the proficiency level is above a threshold value introduced by the teacher.

In order to implement the different strategies, the partners of the project focus on SGs that are based on activities that typically correspond to levels in SGs. These SG activities contain the tasks that learners can perform to train specific competences. Besides, SGs activities have to be independent from each other. The aim is to allow organising the SG activities in different ways and hence create diverse learning paths. Therefore, the SGs in the project can be considered as curriculum sequencing environments in the sense that learning paths can be defined as a set of independent entities that can be assembled in different ways [11].

As representative works of curriculum sequencing environments we can cite the adaptive hypermedia [11] or ALEKS (www.aleks.com), an environment of a commercial spin off of the University of California at Irvine. The concept of curriculum sequencing is grounded on Knowledge Space Theory (KST) [12]. Thus, in order to provide with a feasible implementation for the different strategies, we based our work on KST, and more precisely on its extension: Competence-based Knowledge Space Theory (CbKST) [6,13], as a potential framework for adapting learning paths in SGs.

2.2 Competence-based Knowledge Space Theory (CbKST)

CbKST is an extension of KST [12]. KST was intended for the assessment of learners' knowledge. Advancements of KST introduce a separation of observable performances and the underlying abilities or knowledge, leading to diverse competence-based approaches [14]. CbKST relies on three main concepts: precedence relations, competence states and the competence structure. Basically CbKST assumes a defined set of competences and precedence relations between them. In other words, a precedence relation $a \leq b$ indicates that competence 'a' is a prerequisite to acquire another competence 'b'. Considering precedence relations, competence states are the resulting meaningful combinations of single competences. A competence structure is obtained by deriving all the admissible competence states of a certain domain. Figure 1 shows an example of precedence relations between five competences and the competence structure. In this example, the set a, c cannot be a competence state since competence 'b' is also required to master competence 'c'.

Given a competence structure, the lowest competence state represents the naive state (i.e. the learner has not mastered any competence yet) and the highest competence state represents the state in which the learner has mastered all the competences for a given domain. Then, a learning path represents a possible path in the competence structure that moves from the lowest competence state to the highest one.

There are diverse research works on adapting SGs based on CbKST [4,5,15,16]. However, while the identified literature focuses on the traditional approach based on improving learners' competences, as far as we know there is a lack of research studies that consider teachers' needs as a factor when implementing adaptive SGs. For this reason, we also introduce teachers' decisions as an input to enhance adaptation in SGs.

In the next section, we describe the architecture to implement the recommendation strategies to suggest SG activities considering the requirements expressed by teachers.

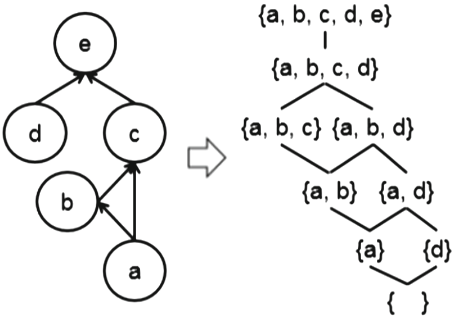


Fig. 1. Example of precedence relations (left graph) and competence structure (right graph).

3 Architecture of the Decision Module

We propose the development of a decision module based on an adaptation model proposed by Kopeinik et al. [5] in order to implement the different recommendation strategies. Like Kopeinik et al., we consider the learner's current competences. In addition, in our approach we consider the teachers' decisions that mainly deal with selecting one of the identified recommendation strategies. Also, we consider recreational competences of SG activities. The overall logic architecture of the decision module is depicted in Fig. 2.

In order to implement the recommendation strategies and hence achieve adaptation, the decision module considers the following elements to suggest learning paths in SGs:

– The domain model of the SG. This means, the pedagogical competences and the links between competences. This information is used to build the competence structure based on CbKST.
– The recreational competences. Together with the domain model, these competences define the game requirements to a particular SG. The domain model and recreational competences do not change during the game process.
– The list of activities (or levels). Each activity can be linked to pedagogical competences, as well as recreational competences. An activity corresponds to a way to perform a task in an SG. In our work, we define an activity as a basic unit and it corresponds to a level within an SG.
– The learner model. This model keeps track of the activities performed by the learner and it stores the accumulated evidence about competences. This means, each competence has a value corresponding to the probability that a learner master this competence. Initially, a learner assessment is done before playing the game to initialize the confidence or probabilistic values. These probabilistic values are changing during the game playing (after the learner has finished each activity). As mentioned before in the Sect. 2.1, in the context of the project, we also work on a monitoring tool that computes these

probabilistic values. This work, which is out of the scope of this paper, extends a previous work [17] by using Bayesian networks.

– The recommendation strategies that the teacher can choose. These are: (a) "Advancing": suggests activities that address the same competences as those in the current learner's competence state and moves one step forward in the competence structure; (b) "Reinforcing": suggests activities that address a subset of competences specified by the teacher. The percentage of accomplishment of the selected competences must be below a certain threshold (value that has to be reached by the learner for improving the competences in which he/she is weaker); and (c) "Deepening": also suggests activities that address a subset of competences specified by the teacher. Unlike "Reinforcing" strategy, the percentage of accomplishment of the selected competences must be above a certain threshold value specified by the teacher. This value indicates that the learner is good in the set of competences and the teacher aims that he/she becomes better.

Next sections focus on describing the different modules of the decision module.

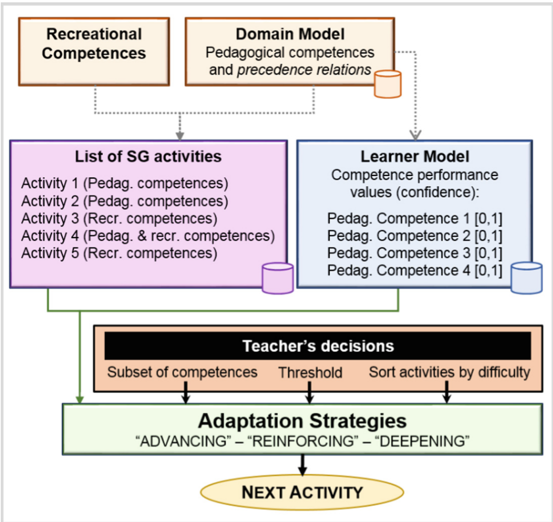


Fig. 2. Logic architecture of the decision module.

3.1 Domain Model

The XML schema of the domain model is depicted in Fig. 3. Each competence of the domain model is composed by the following attributes: "Id", "Name", and "Level". The different relations between competences are described in the "Link-list" element. Each "Link" is composed by the following attributes: (a) an id ("Id"); (b) a reference to the id of a source competence ("SourceId");

(c) a reference to the id of a target competence ("TargetId"); and (d) the type of relations (attribute "Name"), being "composition", "prerequisite" or "precedence" the possible values.

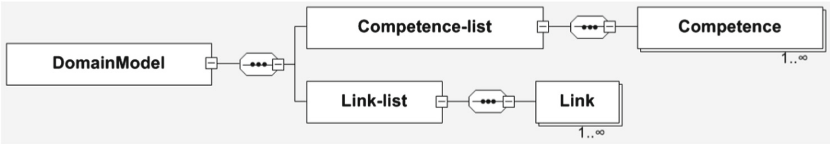


Fig. 3. Graphical representation of the domain model.

3.2 Learner Model

The learner model stores the information about the confidences associated to each competence of the domain model. This model also stores the information about the activities done by the learners. The information of the learner model (element "LearnerModel-Extended") is defined in a XML document compliant with the schema depicted in Fig. 4. The element "LearnerModel" contains the list of competences of the domain model. Each competence (element "Competence") contains the following attributes: a reference to the id of a competence defined in the domain model (attribute "Id"), a reference to the name of the competence ("Name"), and the confidence value for the competence ("Confidence"). The "LearnerModel-Extended" also stores the information about the list of activities performed by the learner (element "LearnerActivity"). Each activity done by the learner (element "Activity") contains the following attributes: "Id", "Name", and "Difficulty".

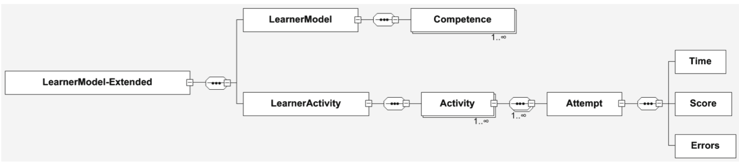


Fig. 4. Graphical representation of the learner model.

3.3 Recommendation Strategies

The recommendation module of the decision module implements three different strategies that depend on the purpose of the teacher. The strategies consider the competence structures based on CbKST (Sect. 2.2) for building the competence structure. In particular, these strategies are:

- The "Advancing" strategy that aims at working the maximum number of competences in a certain domain.

- The "Deepening" strategy that aims at providing the learner with activities to become expert in certain competences.
- The "Reinforcing" strategy that aims at providing the learner with activities to reinforce certain competences.

"Advancing" Strategy. The "Advancing" strategy addresses the first requirement identified in the Play Serious project that aims at working the maximum number of competences in a certain domain (S1). This strategy considers the current learner's competence state and moves to the next competence states in order to propose an activity (see Table 1, left).

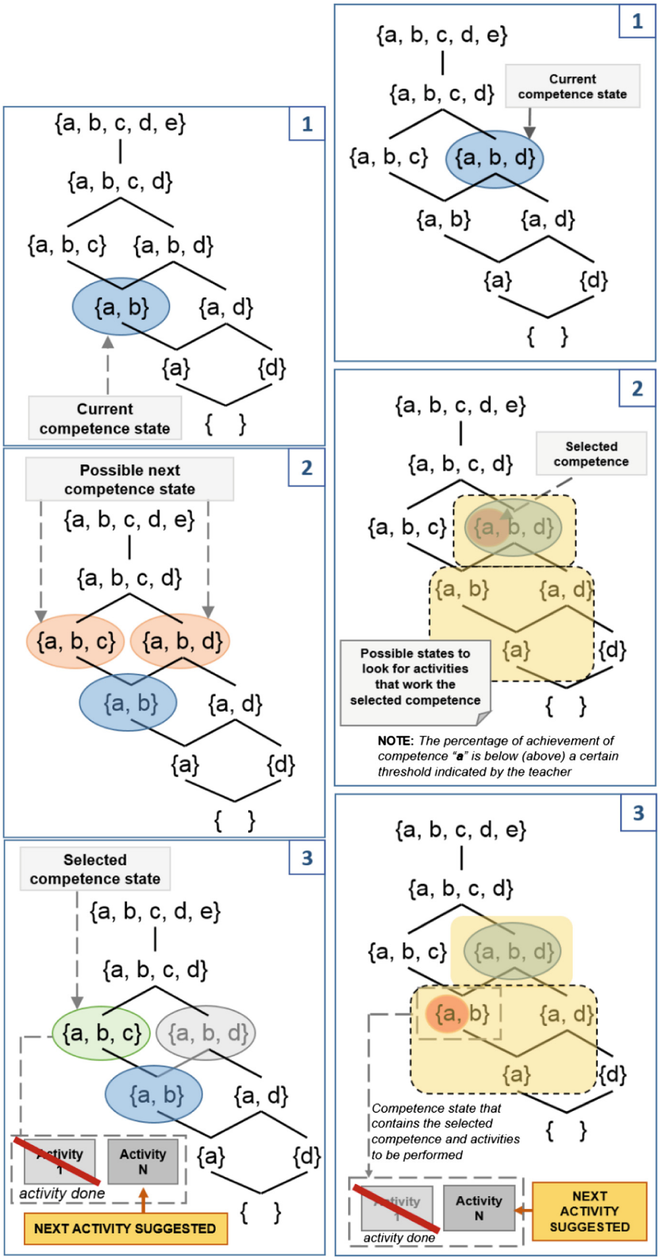
The next activity to be played is suggested as follows.

- First, we get the possible next competence states. Next competence states (i.e. successors) are those which contain exactly the same the competences of the current competence state plus one more (see Table 1, left-1). In CbKST, the additional competences in the successors are the outer fringe of the current competence state.
- Then, we iterate the list of the next competence states. For each competence state, we look at the associated activities that have not been done by the learner (see Table 1, left-3).
- If there are no activities (because there are no activities designed for this competence state), we move to the following competence state.
- If there are activities, we select one of them. The next activity is selected considering the difficulty level, if this option has been selected by the teacher. Otherwise, a random function is applied. Besides, if the pedagogical activity has recreational competences, then if possible, we suggest before an activity that only works the recreational competences (if the learner has not worked on these competences yet).
- If none of the next competence states contain activities, we look at higher knowledge states. This strategy finishes when the last competence state (containing all the competences) is reached.

"Reinforcing" and "Deepening" Strategies. The "Reinforcing" and "Deepening" strategies fit the second and third requirements identified in the Project, respectively. From an algorithmic point of view, the behaviour of "Reinforcing" and "Deepening" strategies is very similar, but they address different pedagogical needs. These are: providing the learner with activities to reinforce certain competences (S2), and with activities to become expert in certain competences (S3).

First, we consider the current learner's competence state and all previous competence states from the competence structure (see Table 1, right-1). The initial state of the algorithm considers the subset of competences selected by a teacher, as well as the specified threshold value. Then, from the subset, we get those competences that are below (in "Reinforcing" strategy) or above (in "Deepening" strategy) a certain threshold specified by the teacher (see Table 1, right-2).

Table 1. Graphical example of the behaviour of the "Advancing" strategy (left). Graphical example of the behaviour of the "Deepening" and "Reinforcing" strategies (right).



From the selected subset of competences, the algorithm follows an iterative process.

– First, we get one competence from the subset of competences.
– Right afterwards, we look at the previous competence states (from the initial to the current learner's state) that contain the selected competence to be worked (see Table 1, right-2).
– Then, for each of these competence states we get the activities that have not been done yet (see Table 1, right-3).
– Similarly to the "Advancing" strategy, if there are several activities linked to the competence state, we select the next activity considering the difficulty level if specified by the teacher. Otherwise, a random function is performed to suggest the next activity. Besides, if the selected pedagogical activity has recreational requirements, then if possible, we suggest before an activity that only works the recreational requirements.
– However, if we reach the current learner's competence state and no activities has been found for the selected competence, we choose another competence from the considered subset of competences, and we repeat the process.
– The strategy ends when the threshold is reached (in "Reinforcing") or when the maximum level of proficiency has been reached (in "Deepening"). Otherwise, both strategies can also end when all activities for the subset of competences have been done.

Next section presents an evaluation of the strategies in "Les Cristaux d'Éhère" [18], an SG for teaching physics.

4 Evaluation

The different algorithms have been evaluated on the SG called "Les Cristaux d'Éhère", designed to teach concepts related to physics consisting of 18 activities. The goal for each level is to solve problems about competences related to water state changes. Learners must move an avatar to interact with certain objects to reach a solution concerning physics-related topics.

A secondary education teacher, expert on physics, designed the domain model for the SG (see Fig. 5). From this domain model (i.e. precedence relations between competences), we generated the competence structure.

The teacher also created the Q-Matrix [19]; i.e. he linked the SG activities to the worked competences considering the tasks that can be performed in each activity (see Fig. 6). Besides, the different SG activities were linked to competence states (the set of competences worked on in each activity forms the competence state).

Considering these information, an evaluation has been carried out considering the competence structure created from the domain model of "Les Cristaux d'Éhère". In particular, we compared the results obtained from the competence structure based on the domain model with answers provided by the secondary education teachers involved in the definition of the domain model.

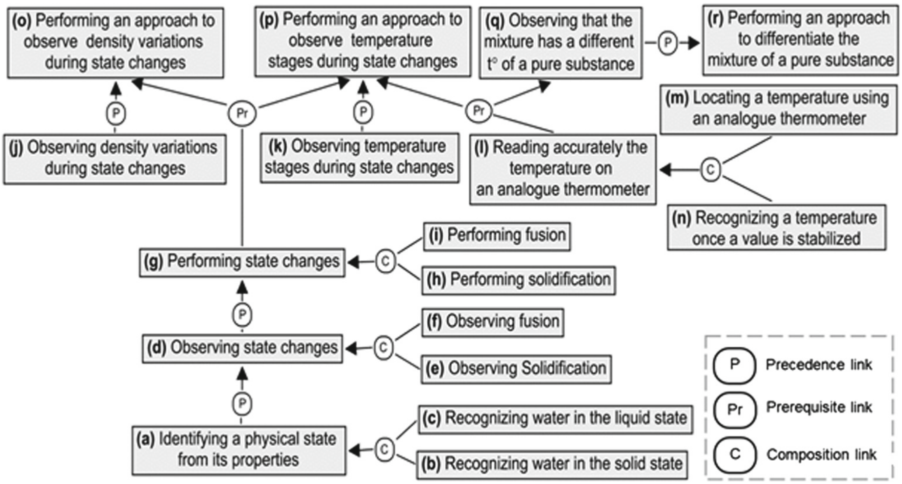


Fig. 5. Domain model for "Les Cristaux d'Éhère".

4.1 Results Obtained from the Implemented Recommendation Strategies

We have specified different input parameters to evaluate the three implemented strategies. Concretely, we have defined seven tests with different CSs (Competence states) as starting point, as well as concrete set of competences and threshold values to be used by "Reinforcing" and "Deepening" strategies. Using this information, Fig. 7 shows the results of applying the adaptation strategies to the competence structure.

Furthermore, expected results can be inferred by looking at the competence structure that contains the SG activities and related CSs. Thus, these expected results (used for validating the obtained results shown in Fig. 7) are explained as follows:

– Test 1: The learner is in the initial CS and no previous activities has been done. In this case, it makes no sense to apply Reinforcing or Deepening strategies since no competences have been previously worked. However, if we apply Advancing strategy, we have to look at CSs that only contain one competence. Thus, the expected result is only the "Act1" that belong to the CS "[m]".
– Test 2: The learner's CS is "[m, n]" and no previous activities have been done. Besides, the system confidence for competence 'm' is 0.7, and for competence 'n' is 0.4. If we apply the different strategies the expected results are:
  - "Advancing" strategy: This strategy is expected to suggest activities from CSs "[b, f, m, n]" or "[b, e, m, n]" (i.e. successors of current CS that contain activities). This means, that potential activities to be suggested are "Act4" or "Act5", respectively.
  - "Deepening" strategy for competence 'm' and a threshold value of 0.6: This strategy is expected to suggest an activity from previous CSs; i.e. from the initial CS to the current CS. That means, CS "[m]", and therefore, "Act1".

Activities	b	c	e	f	h	i	j	k	m	n	o	p	q	r	*Competence States (CSs)*
Act1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	{m}
Act2	0	0	0	0	0	0	0	0	1	0	0	0	1	1	{m, q, r}
Act3	0	0	1	1	0	0	0	0	1	1	0	1	0	0	{e, f, m, n, p}
Act4	1	0	0	1	0	0	0	0	1	1	0	0	0	0	{b, f, m, n}
Act5	1	0	1	0	0	0	0	0	1	1	0	0	0	0	{b, e, m, n}
Act6	1	1	0	1	0	1	0	1	1	0	0	0	0	0	{b, c, f, i, k, m}
Act7	1	1	0	1	0	1	0	1	1	1	0	0	0	0	{b, c, f, i, k, m, n}
Act8	0	1	1	0	1	0	1	1	0	0	0	0	0	0	{c, e, h, j, k}
Act9	0	1	1	1	1	1	0	0	1	1	0	0	1	0	{c, e, f, h, i, m, n, q}
Act10	0	0	0	0	0	0	0	0	1	1	0	0	0	0	{m, n}
Act11	0	0	0	0	0	0	0	0	1	1	0	0	0	0	{m, n}
Act12	1	1	1	1	1	1	0	1	1	1	0	1	1	0	{b, c, e, f, h, i, k, m, n, p, q}
Act13	1	1	1	1	1	1	1	1	1	1	0	1	1	0	{b, c, e, f, h, i, j, k, m, n, p, q}
Act14	1	1	1	1	1	1	1	0	1	1	0	0	1	1	{b, c, e, f, h, i, j, m, n, q, r}
Act15	1	1	1	1	1	1	0	1	1	1	0	0	1	1	{b, c, e, f, h, i, k, m, n, q, r}
Act16	1	1	0	0	1	1	0	1	1	1	0	0	1	1	{b, c, h, i, k, m, n, q, r}
Act17	1	1	1	1	1	1	0	1	1	1	0	1	1	0	{b, c, e, f, h, i, k, m, n, p, q}
Act18	0	0	0	0	1	1	1	0	1	1	1	0	0	0	{h, i, j, m, n, o}

Fig. 6. The Q-matrix representing activities indexation in “Les Cristaux d’Éhère”.

  - “Reinforcing” strategy for competence ‘n’ and a threshold value of 0.4: Since there are not previous CSs with competence ‘n’ that contain activities, this strategy is expected to suggest an activity from CS “[m, n]”, and therefore, “Act10” or “Act11”.
- Test 3: Similar to Test 2, but in this case we consider that the learner has already done the activities “Act1” and “Act10”. For this case, the expected results are:
  - “Advancing” strategy: Same expected result as in Test 2, since the activities done by the learner do not influence in next CSs. Thus, “Act4” or “Act5” are expected to be suggested.
  - “Deepening” strategy for competence ‘m’ and a threshold value of 0.6: Since “Act1” has been done and there are not more previous CSs with competence ‘m’ that contain activities, this strategy is expected to suggest an activity from CS “[m, n]”. Besides since “Act10” is also done, the only expected activity to be suggested is “Act11”.
  - “Reinforcing” strategy for competence ‘n’ and a threshold value of 0.4: Since there are not previous CSs with competence ‘n’ that contain activities, this strategy is expected to suggest an activity from CS “[m, n]”. Besides since “Act10” is already done, the only expected activity to be suggested is “Act11”.
- Test 4: The current learner’s CS is “[b, e, m, n]” and no previous activities have been done. Besides, the system confidence for the different competences are: ‘b’ = 0.3, ‘e’ = 0.3, ‘m’ = 0.8, and ‘n’ = 0.4. If we apply the different strategies the expected results are:

  - Advancing strategy: Starting from "[b, e, m, n]", the first successors containing activities are "[b, c, e, f, h, i, j, m, n, q, r]" and "[b, c, e, f, h, i, k, m, n, q, r]". Therefore, "Act14" and "Act15" are expected to be suggested, respectively.
  - Deepening strategy for competence 'm' and a threshold value of 0.6: This strategy is expected to suggest an activity from previous CS "[m]", and therefore, "Act1".
  - Reinforcing strategy for competence 'b' and a threshold value of 0.4: There are not previous CSs with competence 'b' that contain activities. Then, this strategy is expected to suggest activities from CSs "[b, e, m, n]", and therefore "Act5".
- Test 5: Same as Test 4 but considering that the learner has already done the activities "Act1", "Act10", and "Act11". Then, the expected results are:
  - Advancing strategy: Same expected result as in Test 4, since the activities done by the learner do not influence in next CSs. Thus, "Act14" and "Act15" are expected to be suggested.
  - Deepening strategy for competence 'm' and a threshold value of 0.6: Since "Act1", "Act10", and "Act11" have been done, previous CSs "[m]" and "[m, n]" cannot be suggested. The only expected activity to be suggested is "Act5" from CS "[b, e, m, n]".
  - Reinforcing strategy for competence 'b' and a threshold value of 0.4: There are not previous CSs with competence 'b' that contain activities. Then, this strategy is expected to suggest activities from CSs "[b, e, m, n]", and therefore "Act5".
- Test 6: The learner's CS is "[b, c, e, f, h, i, k, m, n, q]" and no previous activities have been done. Besides, the system confidence for the different competences are: 'b' = 0.3, 'c' = 0.4, 'e' = 0.3, 'f' = 0.4, 'h' = 0.4, 'i' = 0.4, 'k' = 0.5, 'm' = 0.7, 'n' = 0.5, and 'q' = 0.8. If we apply the different strategies the expected results are:
  - Advancing strategy: This strategy will look at the direct highest CSs containing activities. From current CS, the direct highest CSs are "[b, c, e, f, h, i, k, m, n, q, r]" and "[b, c, e, f, h, i, k, m, n, p, q]". Thus, expected activity to be suggested are "Act12", "Act15", and "Act17".
  - Deepening strategy for competence 'm' or 'q' and a threshold value of 0.6: This strategy is expected to suggest activities from lowest-level previous CSs that contain 'm' or 'q'. Thus, expected activity is "Act1" from CS "[m]".
  - Reinforcing strategy for competence 'b' or 'e' and a threshold value of 0.4: This strategy is expected to suggest activities from lowest-level previous CSs that contain 'b' or 'e'. Thus, expected activity is "Act5" from CSs "[b, e, m, n]".
- Test 7: Same as Test 6 but considering that the learner has already done the activities "Act1", "Act2", "Act4", "Act5", "Act10", and "Act11". Following the same reasoning as in Test 6, expected activities are:
  - Advancing strategy: Same expected result as in Test 6, since the activities done by the learner do not influence in next CSs. Thus, "Act12", "Act15", and "Act17" are expected to be suggested.

Tests	Current CS	Subset of competences and threshold (if applicable)	Activities done	System confidence	Suggested activity		
					Using the competence structure built by the domain model		
					Advancing	Deepening	Reinforcing
Test 1	Initial state ø	-	-	-	Act1	None	None
Test 2	[m, n]	[m] - 0.6 Deep. [n] - 0.4 Reinf.	-	[m] 0.7 [n] 0.4	Act5	Act1	Act10
Test 3	[m, n]	[m] - 0.6 Deep. [n] - 0.4 Reinf.	Act1 Act10	[m] 0.7 [n] 0.4	Act5	Act11	Act11
Test 4	[b, e, m, n]	[m] - 0.6 Deep. [b] - 0.4 Reinf.	-	[b] 0.3 [e] 0.3 [m] 0.8 [n] 0.4	Act14	Act1	Act5
Test 5	[b, e, m, n]	[m] - 0.6 Deep. [b] - 0.4 Reinf.	Act1 Act10 Act11	[b] 0.3 [e] 0.3 [m] 0.8 [n] 0.4	Act14	Act5	Act5
Test 6	[b, c, e, f, h, i, k, m, n, q]	[m,q] - 0.6 Deep. [b,e] - 0.4 Reinf.	-	[b] 0.3 [c] 0.4 [e] 0.3 [f] 0.4 [h] 0.4 [i] 0.4 [k] 0.5 [m] 0.7 [n] 0.5 [q] 0.8	Act15	Act1	Act5
Test 7	[b, c, e, f, h, i, k, m, n, q]	[m,q] - 0.6 Deep. [b,e] - 0.4 Reinf.	Act1 Act2 Act4 Act5 Act10 Act11	[b] 0.3 [c] 0.4 [e] 0.3 [f] 0.4 [h] 0.4 [i] 0.4 [k] 0.5 [m] 0.7 [n] 0.5 [q] 0.8	Act15	Act6	Act6

Fig. 7. Results obtained when applying the recommendation strategies to the competence structure built from the domain model of "Les Cristaux d'Éhère".

- Deepening strategy for competence 'm' or 'q' and a threshold value of 0.6: Since "Act1", "Act2", "Act4", "Act5", "Act10", and "Act11" have been done, previous CSs "[m]", "[m, q, r]", "[b, f, m, n]", "[b, e, m, n]" and "[m, n]" cannot be suggested. The only expected activity to be suggested is "Act6" from CS "[b, c, f, i, k, m]".
- Reinforcing strategy for competence 'b' or 'e' and a threshold value of 0.4: This strategy is expected to suggest activities from lowest-level previous CSs that contain 'b' or 'e'. CSs "[b, f, m, n]" and "[b, e, m, n]" cannot be suggested since activities "Act4" and "Act5" have been done. Thus, expected activity is "Act6" from CSs "[b, c, f, i, k, m]".

Next section describes an evaluation with the secondary teacher involved in the definition of the domain model and the Q-Matrix for "Les Cristaux d'Ehère". We propose the teacher to suggest activities based on the aforementioned tests. The comparison between the answers provided by the teachers and the obtained results from the strategies will provide insights on the relevance of the proposed approach.

4.2 Results Obtained from the Teacher's Answers

We carried out an evaluation with the secondary teacher involved in the definition of the domain model (Fig. 5) and the Q-Matrix (Fig. 6) for "Les Cristaux d'Ehère". We described the three adaptation strategies to the teacher. In order to not influence the teacher's answers, we did not explain the concepts related to CbKST; i.e. we did not explain that decisions on suggested activities are based on the competence structure. Then, we proposed the teacher to suggest activities based on the same situations (i.e. tests) as presented in Fig. 7. In order to gather his answers, we designed a questionnaire based on multiple-choice questions in which the teacher had to select the suggested activity (or activities) for each situation. In order to simplify the description of the different situations, we did not include the information about the system confidence. The confidence values are probabilistic numbers computed by the system, and therefore, this information is not relevant to be considered by the teacher. For instance, the description provided to the teacher for the situation of test 2 was: "Imagine a situation in which a student has played "Les Cristaux d'Ehère". Besides, the student has knowledge on: [m] Locating a temperature using an analogue thermometer, and [n] Recognizing a temperature once a value is stabilized. Considering this situation, you have to select the activity that you will suggest your student for: (1) advancing; (2) deepening in competence 'm'; and reinforcing competence 'n' ".

Once the teacher filled the questionnaire, we compared his answers with the results obtained from the implemented recommendation strategies (described in Sect. 4.1). From this comparison, we notice that there were several cases in which the answers provided by the teacher (see Fig. 8) differ from the expected results.

Tests	Current CS	Subset of competences (if applicable)	Activities done	Suggested activity		
				Advancing	Deepening	Reinforcing
Test 1	Initial state ∅	-	-	Act6 (*Case 1*)	-	-
Test 2	[m, n]	[m] Deepening [n] Reinforcing	-	Act6 (*Case 2*)	Act10 (*Case 3*)	Act3 (*Case 4*)
Test 3	[m, n]	[m] Deepening [n] Reinforcing	Act1, Act10	Act4 (*OK*)	Act9 (*Case 4*)	Act5 (*Case 4*)
Test 4	[b, e, m, n]	[m] Deepening [b] Reinforcing	-	Act3 (*Case 2*)	Act10 (*Case 3*)	Act8 (*Case 6*)
Test 5	[b, e, m, n]	[m] Deepening [b] Reinforcing	Act1, Act10 Act11	Act4 (*Case2*)	Act14 (*Case 4*)	Act18 (*Case6*)
Test 6	[b, c, e, f, h, i, k, m, n, q]	[m,q] Deepening [b,e] Reinforcing	-	Act12 (*OK*)	Act2 (*Case 5*)	Act5 (*OK*)
Test 7	[b, c, e, f, h, i, k, m, n, q]	[m,q] Deepening [b,e] Reinforcing	Act1, Act2, Act4, Act5, Act10, Act11	Act14 (*Case 2*)	Act17 (*Case 4*)	Act18 (*Case 6*)

Fig. 8. Results obtained from the teacher's answers.

In order to better understand the suggestions made by the teacher, we meet him and jointly compared and discussed the results. From the joint discussion with the teacher, six different cases were identified that explain the reasons because the teacher's answers were different from the expected results:

- Case 1: For the initial situation in which the learner is in the initial CS and no previous activities has been done, the "Advancing" strategy starts by looking at CSs that contain only one competence. If no activities are found, then the strategy advances forward in higher CSs. In this case the expected result is the "Act1" that belong to the CS "[m]". However the teacher suggested "Act6". The reason behind that is because this activity works competence 'i'. For the teacher, this competence is conceptually easier than competence 'm'. In fact, if we look at the domain model (see Fig. 5) competence 'i' has no precedence competences, while competence 'm' is preceded by other competences. However, the competence structure does not contain any activity for the CS "[i]". The suggestion from the strategy is correct but it is not what the teacher would select.
- Case 2: The "Advancing" strategy moves forward in the learning path by adding one competence to the current learner CS each time. Besides, the "Advancing" strategy only looks at CSs that can be reached from the different learning paths that belong the current CS. The teacher's decision for "Advancing" made sense since he considered the current learner's CS and proposed other activities with higher number of competences. However, considering the competence structure, the proposed activity selected by the teacher is not reachable from the current learner's CS. For instance, when applying the "Advancing" strategy to Test 2, the current CS is "[m, n]" and teacher suggested "Act6". This activity belongs to "[b, c, f, i, k, m]" which is not part of any of the learning paths from the current CS.
- Case 3: For "Deepening" strategy, we only look at the competence to work in depth. However, the teacher also took into account if the competence is part of a composition. In that case, given a competence, the teacher suggested activities that work on not only the intended competence but also all the competences that form the composition. As an example, in test 2, the "Deepening" strategy suggests "Act1" that belongs to the CS [m] for deepening 'm'. However, the teacher suggested "Act10" that belongs to the CS "[m, n]" for working in depth the competence 'm'. If we look at the domain model (see Fig. 5), competences 'm' and 'n' are composition of another competence (i.e. 'l').
- Case 4: "Reinforcing" and "Deepening" strategies consider the current learner's CS and looks at previous CSs to reinforce or work in depth concrete competences, respectively. However, the suggestions made by the teacher considered higher CSs from the current learner's CS. The reasons given by the teacher was: (a) for reinforcing, the teacher aimed to make the learner realise on his/her weaker competences by suggesting a more complex activity, and (b) for deepening, the teacher aimed to push the learner to become experts in concrete competences by working other several competences (i.e. challenging the learner to solve more complex activities). For instance, if learner is in CS [m, n] and we want to work in depth competence 'm', the strategy looks at previous CSs that work 'm', and therefore, the suggested activity could be "Act11". However, the teacher suggested "Act9" that work 'm' but also competences 'c', 'e', 'f', 'h', 'i', 'n', and 'q'.
- Case 5: From a subset of competences, "Deepening" strategy works on a competence each time. However, teacher considered that the subset of competences

has to be worked on at once. For instance, in test 6, the CS is "[b, c, e, f, h, i, k, m, n, q]" and we aimed to work in depth "[m, q]". The strategy suggested "Act1" that belongs to CS "[m]" while the teacher suggested Act2 that works both competences 'm' and 'n' (i.e. CS "[m, q, r]").
– Case 6: Some mismatches result from problems with the defined Q-Matrix. This issue is also the main reason of having activities that did not match to any of the CSs in the competence structure obtained from the domain model. We were interested in knowing whether the domain model designed by him might contain flaws or these mismatches come from the Q-Matrix. Therefore, the teacher paid attention to the "unconnected" activities by looking at their addressed competences and the domain model. Then, the teacher realised that there were some problems in the Q-Matrix; he missed to relate some of the competences to few activities.

5 Discussion and Future Work

Currently, adaptation is based on improving confidence values computed by systems in regards to the proficiency level of learners. The innovative part of our work is the combination of specific needs expressed by teachers with this traditional approach (i.e. taking into account the current competence state of the learner). This combination has resulted in the successful implementation of a decision module and an authoring tool for adapting learning paths in SGs.

The decision module is based on CbKST and implements three adaptation strategies that address specific teachers' requirements. The adaptation strategies result from the needs expressed by teachers and companies involved in the Play Serious project. The implementation of these strategies is based on different input parameters (mainly, subset of competences and threshold). We believe that the proposed approaches can be extended and applied to other pedagogical needs, as long as these needs can be translated into the concepts of CbKST (i.e. competence state and competence structure).

Currently, we are testing the implementation of these strategies in different SGs. This research work has also identified several future research lines:

– assessing learners by applying the proposed strategies and evaluating the impact on learners' performance,
– supporting teachers in defining the granularity level of competences to define domain models that can be readable and manageable by teachers and computationally built by systems.
– using CbKST as an analytical method to identify gaps in the design of the SGs. Indeed, by using CbKST it is possible to identify competence states for which there are no associated activities.

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References

1. Shute, V., Zapata-Rivera, D.: Adaptive educational systems. In: Durlach, P., Lesgold, A. (eds.) Adaptive Technologies for Training and Education. Cambridge University Press, New York (2012)
2. Göbel, S., Wendel, V., Ritter, C., Steinmetz, R.: Personalized, adaptive digital educational games using narrative game-based learning objects. In: Proceedings of the 5th International Conference on E-Learning and Games, Changchun, China, pp. 438–445 (2010)
3. Hocine, N., Gouaöch, A., Di Loreto, I., Abrouk, L.: Etat de l'art des techniques d'adaptation dans les jeux ludiques et sérieux. Revue d'Intelligence Articielle **25**, 253–280 (2011)
4. Augustin, T., Hockemeyer, C., Kickmeier-Rust, M., Podbregar, P., Reinhard, S., Albert, D.: The simplified updating rule in the formalization of digital educational games. J. Comput. Sci. **4**, 293–303 (2013)
5. Kopeinik, S., Nussbaumer, A., Bedek, M., Albert, D.: Using CbKST for learning path recommendation in game-based learning. In: Proceedings of the 20th International Conference on Computers in Education, Singapore, pp. 26–30 (2012)
6. Heller, J., Mayer, B., Hockemeyer, C., Albert, D.: Competence-based knowledge structures for personalised learning: distributed resources and virtual experiments. Int. J. E-Learning **5**, 75–88 (2006)
7. Marne, B., Labat, J.: Model and authoring tool to help adapt serious games to their educational contexts. Int. J. Learn. Technol. **9**, 161–180 (2014)
8. Santangelo, T., Tomlinson, C.: The application of differentiated instruction in post-secondary environments: benefits, challenges, and future directions. Int. J. Teach. Learn. High. Educ. **20**, 307–323 (2009)
9. Moreno-Ger, P., Burgos, D., Torrente, J.: Digital games in elearning environments: current uses and emerging trends. Simul. Gaming **40**, 669–687 (2009)
10. Play serious project. http://www.playserious.fr/. Accessed 7 October 2015
11. Brusilovsky, P., Vassileva, J.: Course sequencing techniques for large-scale web-based education. Int. J. Continuing Eng. Educ. Life Long Learn. **13**, 75–94 (2003)
12. Falmagne, J.-C., Cosyn, E., Doignon, J.-P., Thiéry, N.: The assessment of knowledge, in theory and in practice. In: Missaoui, R., Schmidt, J. (eds.) ICFCA 2006. LNCS (LNAI), vol. 3874, pp. 61–79. Springer, Heidelberg (2006)
13. Korossy, K.: Modeling knowledge as competence and performance. In: Albert, D., Lukas, J. (eds.) Knowledge Spaces: Theories, Empirical Research, and Applications, pp. 103–132. Lawrence Erlbaum Associates, Mahwah (1999)
14. Reimann, P., Kickmeier-Rust, M., Albert, D.: Problem solving learning environments and assessment: a knowledge space theory approach. Comput. Educ. **64**, 183–193 (2013)
15. Kickmeier-Rust, M., Göbel, S., Albert, D.: 80days: melding adaptive educational technology and adaptive and interactive storytelling in digital educational games. In: Klamma, R., Sharda, N., Fernández-Manjon, B., Kosch, H., Spaniol, M. (eds.) Proceedings of the 1st International Workshop on Story-Telling and Educational Games, Maastricht, The Netherlands (2008)
16. Peirce, N., Conlan, O., Wade, V.: Adaptive educational games: providing non-invasive personalised learning experiences. In: Proceedings of the 2nd IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning, Banff, Canada, pp. 28–35 (2008)

17. Thomas, P., Labat, J.-M., Muratet, M., Yessad, A.: How to evaluate competencies in game-based learning systems automatically? In: Cerri, S.A., Clancey, W.J., Papadourakis, G., Panourgia, K. (eds.) ITS 2012. LNCS, vol. 7315, pp. 168–173. Springer, Heidelberg (2012)
18. Cristaux d'Éhère. http://seriousgames.lip6.fr/Cristaux_Ehere/. Accessed 7 October 2015
19. Tatsuoka, K.: Rule space: an approach for dealing with misconceptions based on item response theory. J. Educ. Meas. **20**, 345–354 (1983)

MOOCs in Higher Education Magazines: A Content Analysis of Internal Stakeholder Perspectives

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Abstract. Higher Education magazines have echoed the rapid spread of MOOCs in Higher Education Institutions (HEIs) since 2012. In their pages, MOOC related articles are proliferating. The focus of such articles has often been the disruptive nature as well as the survival of this new form of open online education, especially the first years. However, there is also a great deal of mentions of how internal stakeholders in HEIs perceive the advent of MOOCs. These perceptions are the object of analysis in this article. Using the Content Analysis (CA) method, MOOC related sources in three Higher Education magazines during 2014 have been analysed against a set of key themes. These themes have been established by combining data from two previous studies: a Content Analysis of MOOC related academic literature, and a set of interviews to internal stakeholders using grounded theory. As the findings indicate, in 2014 the main concerns of internal stakeholders have been the new teaching practices and new work dynamics resulting from the incorporation of MOOCs in their working routines. It is argued that educational media no longer focuses on the debate of the future of MOOCs. Rather, the debate is on how MOOCs should be best implemented from a practitioner's perspective.

Keywords: MOOCs · Content analysis · University stakeholders · HE magazines

1 Introduction

Higher Education (HE) magazines could be considered as valuable sources of information about the latest developments in Universities. Although they may not have the academic rigour of peer-reviewed publications, they contain up-to-date accounts of the main concerns of universities staff members, especially regarding new technologically supported approaches such as MOOCs. In these magazines, journalists can reflect the opinions of internal stakeholders with a much shorter publication time span than other publications. HE magazines are also more likely to arrive to audiences who may not belong to the area of expertise of the articles. This is specially the case of the representation of MOOCs in this kind of publications. The MOOC scene changes so quickly that academic publications struggle to provide fresh portraits of the situation. HE magazines and news media have echoed the spread of MOOCs with a dramatic increase of MOOC related articles in their pages [1]. Although some events may reflect a decline in the

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interest of news media in MOOCs [2] since Pappano's famous announcement of the "Year of the MOOC" [3], there seems to be a sustained feed of MOOC stories in all sorts of written media. This is especially so in digital media, as suggested by Downes' [4] tracking of MOOC mentions since 2012.

In many Higher Education Institutions, discussions of MOOCs are no longer confined to educational technology departments. Instead, these conversations have spread to faculties at all levels. Beyond the debates over their disruptive potential on one extreme, and their survival on the other [5, 6], MOOCs are often the topic of everyday conversations in many universities, since they are no longer a subject of speculation and prediction, but a matter of present practice.

MOOCs have effects not only on the learners who take them, but also on the highly varied teams of university staff involved in their creation and delivery. As soon as the governance body of a university makes the decision to go ahead with a MOOC project, a number of concerns and conversations arise within the institution. An action plan is designed, often in the absence of protocols and previous experience. The allocation of budgets, roles, and responsibilities becomes a task which is new to most members of the MOOC team. Universities often share experiences of these processes in interim reports [7–9], explaining the organisational challenges and implications encountered when embarking on MOOC development and delivery. These implications for institutions are also explained in a number of white papers [10, 11], containing sets of recommendations for faculty boards and other decision making bodies.

This study aims to inform both practitioners and decision makers about the main current concerns in universities regarding MOOCs. The intention is to provide an account of these concerns in terms of what motivates universities attempt to incorporate MOOCs into their educational offerings, and how this motivation is changing or evolving as understandings of MOOCs change, and as the courses themselves evolve. It will also attempt to determine the main perceived implications of embarking on such an endeavour, and what aspects of MOOC implementation are most discussed both in the media and in HEIs.

2 Related Work

Much meta research exists which reviews different aspects of the state-of-the-art of MOOCs by systematic analyses of the publications on MOOCs, both academic and non-academic. Perhaps one of the most cited is [12], which classifies and categorizes 45 peer-reviewed studies on MOOCs, and identifies important research gaps such as assessment and intercultural communication issues. Further to this study, [13] ran a template analysis on a broader set of papers, identifying assessment and accreditation as key issues. BIS [14] included journalistic articles, academic papers and blogs to explore perspectives on the impact of MOOCs on both institutions and learners, identifying a high degree of both enthusiasm and skepticism. Other studies focus on more popular sources, such as [1], which analyzed news media discourse related to MOOCs to examine the acceptance of this form of education among professional communities and a more general audience.

The current study drew on commonalities in the findings of a content analysis of grey literature on MOOCs [15] and a grounded theory study of internal HE stakeholders involved in MOOC development [16] to establish a set of 12 themes related to MOOC development in HE. A keyword search of a corpus of educational media articles published in 2014 was then conducted, and the search results analysed for their relevance to these themes. This study focuses on Higher Education Institutions, showing primarily their perspective. As such, the perspectives of learners, or other stakeholders such as platform providers (Coursera, Futurelearn, EdX) are outside the scope of this study.

3 Methodology

This study was carried out in two stages, as shown in Fig. 1 below. The first stage involved an examination of two independent studies in which a convergence was identified. This convergence consisted of a set of themes that fed the second stage. The second stage involved a quantified examination of the occurrences of these themes in a corpus of specialist HE magazine articles in 2014.

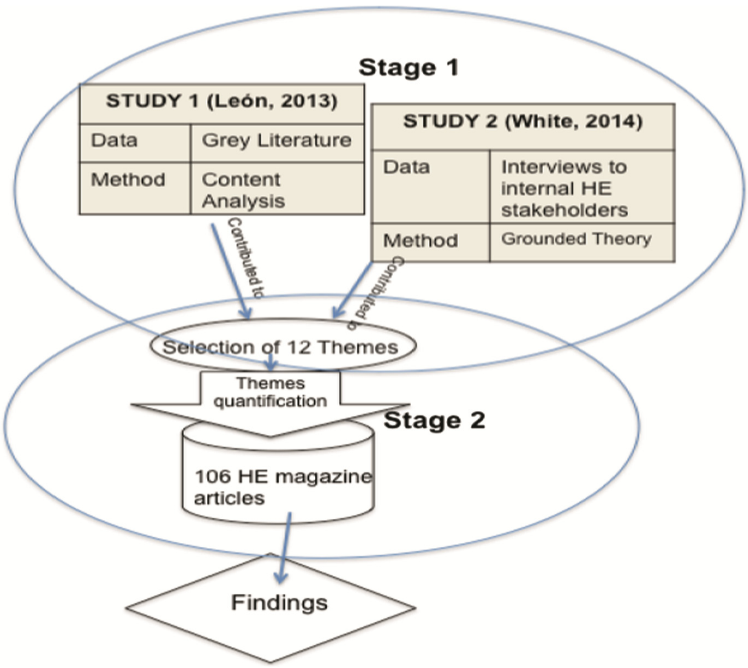

Fig. 1. Stages of the methodology.

3.1 Desk Study, Content Analysis

In summer 2013, a desk study was carried out in order to identify current debates on MOOCs at that time [15]. By then, there was already a broad body of literature, both grey and academic peer-reviewed that contributed to a polarised debate between enthusiasts and skeptics [14]. The main search strategy used for this study consisted of following reputed learning technologists in a social site called Scoop.it, and gathering their curations. This way, all sources had already passed at least one filter of relevance and rigour, and disregarded those identified as having been written with an intention of promoting MOOCs for profit seeking rather than offering objective accounts of their pedagogical potential, in line with [17].

Once the sources were gathered, they were analysed with a method inspired Content Analysis [18], and Herring's [19] recommendations for carrying out content analysis on literature published online. The themes identified in the project were MOOC quality, sustainability, and impact, and debates were explored in a corpus of 60 articles in total.

3.2 Interviews, Grounded Theory

The interview-based study used grounded theory analysis of interview data to explore motivations behind MOOC creation and implementation at the University of Southampton from the perspective of internal (university staff) stakeholders in the development process [16]. The university currently runs 8 MOOCs and has been a member of the FutureLearn consortium, a profit making MOOC venture with a current membership of 40 institutions [20], since its launch in September 2013. In the study, 12 individuals were interviewed as representatives of four main internal stakeholder groups: management, content specialists (lecturers), learning designers, and course facilitators and librarians. A two-stage process for stakeholder identification, following [21] was used.

In the absence of formal institutional policy on the specific aims of MOOC development, stakeholders were interviewed in order to reveal their perceptions of the aims of the university in developing MOOCs, and the stakeholders' own aims in participating in the development process.

3.3 Theme Selection

Similarities and differences exist in the aims, procedures and applications of grounded theory and qualitative content analysis. However, as recognised in [22], commonalities exist in terms of coding and categorising data, and identification of underlying themes. Examination of the desk study and grounded theory interview data at this level of analysis revealed 12 common themes relevant to institutional motivations in MOOC development and the implications of these developments:

- MOOCs as impact on teaching practice: A frequently cited idea was that the development and implementation of MOOCs will have some influence on the way teaching is conducted in HEIs (whether online or face-to-face).
- MOOCs as HEI's social mission: Different HEIs (and the media which comment on them) perceive a range of ways in which an institution can fulfil its social mission, for example by disseminating knowledge, supporting learning, or fostering research.
- MOOCs as institutional strategy for keeping up with HE evolution: Perceptions of institutional motivations for MOOC development were varied, but were often seen

as simply a way for institutions to keep pace with broader developments in higher education.
- MOOCs as the avant-garde of new online education provision: Some observers of MOOCs perceive them as an opportunity to experiment and be creative in higher education, rather than as a more instrumental means to some strategic goal.
- MOOCs as learner data providers: The interviews and articles touched on the potential value various kinds of learner data produced in MOOCs.
- Learning analytics inform learning design: This theme focuses on a more specific use of learner data than the above. The potential for leveraging learning analytics was cited as a motivation in the development and use of MOOCs.
- New relationships between departments, new work dynamics: A wide range of changes in the way individuals, departments, and institutions act and interact as a result of MOOC development were cited in the literature review and interviews.
- MOOCs as new business models: This concern was widely cited in interviews and the literature, although limited levels of consensus or certainty emerged.
- MOOCs as means to engage with large numbers of learners: HEIs' attempts to grapple with the challenges of massive learner numbers and learn from the experience. Although massiveness has regularly been cited as an obvious attraction in terms of business models, it was also seen as an important and distinctive feature of MOOCs in more general educational terms.
- MOOCs as marketing: The potential of MOOCs to act as marketing tools was cited in the previous studies as a key institutional driver for MOOC development, and linked to the general sense of 'hype' surrounding them.
- MOOCs and accreditation: Mention was made in the literature and interviews of the options for and challenges of providing accreditation for MOOCs, and the uncertainty that exists in this area.
- MOOCs and completion rates: Completion rates for MOOCs were a concern that arose in the previous studies, though opinion varied on the importance of completion rates for this kind of course, and the comparability of MOOCs and more traditional courses in this respect.

3.4 The Sample

The study focused on articles from 3 mainstream educational media publications that have high visibility on the Web (rather than peer-reviewed journal articles). These media (Times Higher Education, The Chronicle of Higher Education, and Inside Higher Education) are widely seen as "authoritative sources on higher education" [1] and provide insight into the extent to which concerns of HE professionals related to MOOCs are reflected in mainstream media.

All magazine digital editions contained a search engine, which facilitated the task of searching for the keyword MOOCs in each of them. Only articles including some substantive focus on the relevant MOOC themes were included - those which contained only passing references to MOOCs, or no discussion of the selected themes were disregarded. In total, a corpus of 106 articles from the three magazines was analysed.

4 Findings

Figure 2 depicts the frequency with which each selected theme occurred in the corpus of articles. The overwhelming majority of occurrences relate to how MOOCs are making an impact on teaching practice (this theme was detected in 57 articles - more than half of the sample). There were frequent discussions of the perceived pedagogical benefits for institutions when engaging in MOOCs. For example, Levander [23] reports how Rice University has developed a portfolio of over 40 MOOCs motivated by what they call 'assets', both in terms of materials and teaching experience: building high quality content that can be reused and repurposed, and providing valuable experience of how to develop and deliver these materials. Talbert [24] also shares his experience of screencasting for flipped classrooms as a novel pedagogical approach in university lectures. Many of the articles in which this theme was identified report in one way or another how teachers are adapting their teaching practices to cater for new audiences, delivering through new communication channels and platforms, and attempting to overcome the different challenges that MOOCs pose to educators.

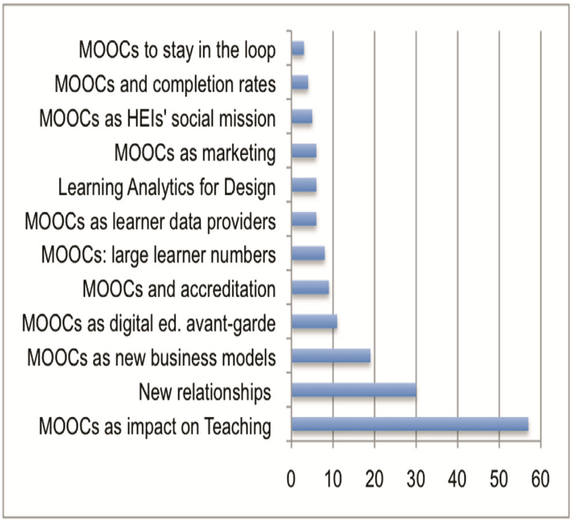

Fig. 2. Theme frequencies in article corpus.

The theme of MOOCs as catalysts of change in relationships between departments and work dynamics in universities was also frequently cited (30 instances). Descriptions of developments in the ways educational materials are collaboratively produced within institutions were common, with MOOC projects requiring cooperation between teaching staff, educational technologists, researchers, librarians, media producers, legal advisors and others. Dulin Salisbury [25], for example, highlights the need for 'team-based course design'. Academic staff cannot develop a MOOC on their own. Instead, they need to liaise with learning designers, media teams, legal services, and librarians. These are no longer ancillary services, but essential parts of the machinery to craft these new educational products. This collaborative task tends to happen within the university. Institutional consortia created around platforms privilege internal capacity building over outsourcing options, which involves collaborative work within different roles at the universities. There are others who suggest new relationships even beyond the walls of the universities. Straumsheim [26] reports on work to involve local community stakeholders in some aspects of course design at the University of Wisconsin, in a strategic attempt to attract local students.

MOOC business models was the third most frequent theme in the sample literature (in 19 articles). Articles included discussion of more flexible and open MOOC provider platforms. Straumshem [27], described how private companies are taking up the role of drivers of change and innovation in education technology, and warned about the risks of an unregulated growth of ed-tech private companies seeking benefit rather than quality in education. Another article suggests advertising as a source of income to MOOC producers [28]. The article warns against the trend of placing bad quality advertisements in the content streamed over the web. There is a great opportunity for online education to leverage some profit from advertisements, as long as these are relevant and non intrusive.

The fourth most frequent theme concerned the role of MOOCs as a field for experimentation and innovation in online education. A number of articles (n = 11) explored opportunities for creativity in education via MOOCs. Parr [30] for example describes efforts by the Open University to focus on social elements of MOOC course development, and also to explore the possibility for creating "nanodegrees" involving very short courses on specific subjects. These courses addressed at smaller learning communities could be the new formal educational offerings at universities. Another article explains how MOOCs have become "fertile testing grounds" for later on developing SPOCs (small paid/private online courses) in an iterative process in which the learning experience can be refined, especially in terms of study groups formation [31].

The theme of MOOCs and accreditation was mentioned in 9 articles, and was addressed in a number of ways. Straumsheim [32] discussed the potential flexibility in course offerings and accreditation which MOOCs may afford, while Kim [33] notes the possibility for competency based assessment and credentialing.

Two related themes were mentioned in the same number of articles: 'MOOCs as learner data provider' and 'Learning analytics informs learning design'. These themes were mentioned in 6 articles respectively, [34, 35]. Eshleman [34] highlights the value of qualitative learner data for use in a case study of her own institution, whilst also recognising the contribution which learning analytics can make to track student activity online. Kim [28] argues that blended and online learning can provide valuable data for learning analytics studies into the learning process, and that this is a far richer source of data for education research than a simple focus on pass rates or other similar learning outcomes. Straumsheim [29], however, cautions against reliance on an abundance of data produced in MOOCs, as interpreting such raw data can be difficult and time consuming.

The theme of MOOCs as marketing for HEIs was also mentioned in 6 articles. Kolowich [36] notes the possibility of raising the profile of Rice University among pre-college students, while Tyson [37] speculates about the relationship between international student recruitment for US institutions and MOOCs.

5 Discussion

MOOCs as impact on teaching is by far the most frequent theme in the analysed sample. Findings in similar studies place the pedagogical dimension of MOOCs in a lower position. For example, the ranking of MOOC issues in media by Bulfin et al. [1] places pedagogy in the sixth position, behind other issues such as the Higher Education marketplace and the free and open nature of MOOCs. That study, however, analysed a broader sample which included non-specialist newspapers, and included articles from 2013. A reason for this shift in focus could be our institutional perspective and focus on MOOC phenomena: as mentioned in the introduction, this project has been carried out in a university, it is addressed at universities, and seeks to understand what happens in universities. An alternative interpretation could be that of a tendency towards the end of a debate on the disruptive nature of MOOCs.

Changes in departmental relationships and working dynamics was also an important theme identified in both the stage 1 studies and stage 2 corpus analysis of articles from 2014. In the 2014 article corpus analysed in stage 2 of this study, discussions of the new relationships between departments and new work dynamics of institutions involved in MOOC development were identified as the second most frequently occurring theme. This perception of MOOCs as a dynamic for internal institutional change was also identified as a significant concern in interviews with university stakeholders in the grounded theory study from stage 1 of this research. This seems to reflect a recognition that undertaking MOOC development projects influences the way individuals, groups and departments interact and collaborate on such ventures. The corpus of educational media sources report quite widely on these issues, elaborating on examples of collaborative practice or the ways in which individual or departmental interactions have changed or need to change in future. For universities, these changing work dynamics are perceived to be an important implication of participation in MOOC development, perhaps because of the relative novelty of MOOC development processes and initiatives. The focus on this issue in the educational media perhaps reflects further emphasis on MOOCs as a practical concern, rather than a more speculative debate over their potential disruptiveness or survival in HE in the short-term.

6 Conclusion

MOOC related discourses are quickly echoed in Higher Education magazines. This study has taken advantage of this feature to interpret the conversations around MOOCs within staff at universities in year 2014. The study suggests that the most frequent conversation topic has been that of MOOCs as laboratories of new pedagogical approaches. This focus may have shifted from a debate around the disruptive potential of MOOCs in the Higher Education scene. Speculation on whether or not MOOCs will shake up Higher Education seems to have subsided, giving way to discussions on how to best implement them.

MOOCs may not be a change of paradigm, but new relationships are being built as a result of them. Different communication means are being use between learners and educators, and different interactions occur between them. This is also the case in the universities internally, where new work dynamics are happening. Making a MOOC and delivering it requires liaison of staff with different roles, many of which may have never worked together before. Higher Education specialist media has reported that the duties and responsibilities of some established roles may have been altered, and new roles such as that of the learning designer are becoming more prominent.

The present study has drawn on a previous one in which internal stakeholders at universities at different levels in the organizational hierarchy were interviewed. The portrait that Higher Education magazines make of Higher Education Institutions coincides in great measure with the results in the interviews of such study. The accounts of both the interviewees and the content in the magazine articles examined seem to coincide in terms of the main motivations for developing MOOCs. These seem to have become an experimental tool for educational innovation, and the main goal of staff at universities is experimenting new pedagogical approaches through MOOCs. The study suggests that marketing, democratization, social mission, and new business models are still important, although secondary reasons for dedicating resources in open online education.

This study has analysed MOOC related magazine articles in 2014. As future work, it is intended to study the discursive evolution around MOOCs in Higher Education specialist magazines over a longer period, since their inception to the present time. 2012 was described as the year of the MOOC [3]. Other ed-tech commentators have described 2013 as the year of the anti-MOOC [38, 39]. From what has been found in this study, 2014 could be described as the year of MOOC pedagogy. A more detailed and extensive study will attempt to determine to what extent this is true.

References

1. Bulfin, S., Pangrazio, L., Selwyn, N.: Making “MOOCs”: the construction of a new digital higher education within news media discourse. The International Review of Research in Open and Distance Learning (2014). http://bit.ly/1AYkD3r
2. Kolowich, S.: The year media stopped caring about MOOCs. The Chronicle of Higher Education (2014). http://bit.ly/1jFIeeV
3. Pappano, L.: The year of the MOOC. N. Y. Times **2**(12), 2012 (2012)
4. Downes, S.: Measuring MOOC Media (2014). http://bit.ly/1DGWvmc
5. Hollands, F.M., Thirthali, D.: MOOCs: expectations and reality. Full report, New York, USA (May 2014). http://bit.ly/1sLBfoH
6. Kolowich, S.: The MOOC “revolution” may not be as disruptive as some had imagined. The Chronicle of Higher Education (2013). http://bit.ly/1vlHWTH
7. University of Edinburgh: MOOCs @ Edinburgh 2013– Report # 1, Edinburgh, p. 42 (2013). http://www.era.lib.ed.ac.uk/handle/1842/6683
8. Ithaka S + R: Interim Report: A Collaborative Effort to Test MOOCs and Other Online Learning Platforms on Campuses of the University System of Maryland (2013). http://bit.ly/17AB5up
9. University of London: MOOC Report 2013 (2013). http://bit.ly/1qaMvGY
10. Voss, B.D.: Massive Open Online Courses (MOOCs): A Primer for University and College Board Members (2013). http://bit.ly/1EdSO8j

11. Yuan, L., Powell, S.: MOOCs and Open Education: Implications for Higher Education. CETIS, Bolton (2013). http://bit.ly/1AYlWzn
12. Liyanagunawardena, T.R., Adams, A.A., Williams, S.A.: MOOCs: a systematic study of the published literature 2008–2012. The International Review of Research in Open and Distance Learning (2013). http://bit.ly/1vlI85o
13. Yousef, A.M.F., Amine, M., Schroeder, U., Wosnitza, M., Jakobs, H.: MOOCs a review of the state-of-the-art. In: CSEDU, pp. 9–20 (2014)
14. BIS (Department of Business, Innovation and Skills): The maturing of the MOOC: literature review of massive open online courses and other forms of online distance learning (2013). http://bit.ly/1c9qvv0
15. León, M.: Reactions on the emergence of MOOCs in higher education reactions on the emergence of MOOCs (2013). http://bit.ly/1ztBu9C in Higher Education
16. White, S.: Exploring stakeholder perspectives on the development of MOOCs in higher education a case study of the University of Southampton. M.Sc Dissertation (2014). http://bit.ly/1FDNJaZ
17. Daniel, J.: Making sense of MOOCs: musings in a maze of myth, paradox and possibility. J. Interact. Media Educ. **3** (2012). http://bit.ly/19KGOzt
18. Krippendorff, K.: Content Analysis: An Introduction to Its Methodology. Sage, Washington (2012)
19. Herring, S.C.: Web content analysis: expanding the paradigm. International Handbook of Internet Research, pp. 233–249. Springer, The Netherlands (2010)
20. FutureLearn: About (2014). https://www.futurelearn.com/about
21. Chapleo, C., Sims, C.: Stakeholder analysis in higher education. Perspectives **14**(1), 12–20 (2010)
22. Cho, J., Lee, E.: Reducing confusion about grounded theory and qualitative content analysis: similarities and differences. Qual. Rep. **19**(64), 1–20 (2014)
23. Levander, C.: It's all about assets. Inside Higher Education (2014). http://bit.ly/1nbGejR
24. Talbert, R.: Making screencasts: the pedagogical framework. The Chronicle of Higher Education (2014). http://bit.ly/1DGYmr6
25. Dulin, S.: Impacts of MOOCs on higher education. Inside Higher Education (2014). http://bit.ly/1nA2vYA
26. Straumsheim, C.: All things in modulation. Inside Higher Education (2014). http://bit.ly/1sFk9tJ
27. Straumsheim, C.: Profit or progress? Inside Higher Education (2014). http://bit.ly/187FshT
28. Kim, J.: 6 Big Takeaways from the edX Global Forum. Inside Higher Education (2014). http://bit.ly/1r1cxUX
29. Straumsheim, C.: Data, Data Everywhere. Inside Higher Education (2014). http://bit.ly/1z5xScV
30. Parr, C.: Making MOOCs social is the next challenge. Times Higher Education (2014). http://bit.ly/1xk6Vq8
31. Schulman, K., Selzter, M., Herzlinger, R.: Spurring Innovation in healthcare using MOOCS. Inside Higher Education (2014). https://www.insidehighered.com/blogs/higher-ed-beta/spurring-innovation-healthcare-using-moocs
32. Straumsheim, C.: A platform for all purposes. Inside Higher Education (2014). http://bit.ly/1pN6OQK
33. Kim, J.: Saltatory. Inside Higher Education (2014). http://bit.ly/1LjJJuu
34. Eshleman, K.: Are MOOCs working for us? Inside Higher Education (2014). http://bit.ly/1BJXLq0
35. Kim, J.: Here Come the data scientists. Inside Higher Education (2014c). http://bit.ly/Vxh425

36. Kolowich, S.: Competing MOOC providers expand into new territory—and each other's. Chronicle Higher Education (2014). http://bit.ly/1vP3gff
37. Tyson, C.: From MOOC to shining MOOC. Inside Higher Education (2014). http://bit.ly/1vlJ1uL
38. Waters, A.: Top Ed-Tech Trends of 2013: MOOCs and Anti-MOOCs (2013). http://bit.ly/1jG6CgI
39. Bates, T.: Look back in anger? A review of online learning in 2013 (2013). http://bit.ly/1c9qvv0

Textbook Gamification: Methods and Technologies

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Abstract. The digitalization of our society is bringing with it digital media everywhere incl. all levels of education from pre-school to lifelong learning. But school is conservative by nature and reluctant to change. Digital games form the most dynamic area of mediatization and a strong market outperforming by the rate of growth any other media business. Digital games attract players of all ages. In response, game-based learning is flourishing. But also textbook publishers have reasons to be reluctant. Although there is a trend toward digital textbooks, playfulness is rare. Textbook gamification is a novel approach to overcome this deficiency. It is pragmatic and efficient, because it builds upon the existing digital material of available textbooks. Particular game categories prove to be effective for the transformation of learning material into a playful form. Webble technology provides the matching IT concepts for gamification. Practical game design and development is demonstrated.

1 Motivation

It is custom to say that modern information and communication technologies are pervading the whole society and our daily life. Strictly speaking, this is not true.

It is not the technology which is changing our lives. It is the way in which we adopt and adapt technologies. Some readers may share the opinion that there are areas in which modern information and communication technology (ICT) is over-represented and misused–think of cellphones in restaurants and theaters. In other areas, however, the exploitation of modern ICT is behind its potential. This is the motivation underlying the authors' present approach.

Apparently, digital games are a form of contemporary digital media which attract enormous numbers of human players. The digital games business is outperforming all other legal business areas. Recently, very successful commercial games generated a turnover of one billion $ within only three days on the market. Financial success like this is boosting the interest in digital games. In contrast, the interest in digital games for learning, training, and coaching is diminutive.

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This paper is based on the third author's Bachelor thesis [1] and on the authors' common predecessor CSEDU paper [2].

2 Game-Based Learning

Game-Based Learning (GBL, for short) sounds like the promise to amalgamate, on the one hand, the attractiveness of playing digital games with, on the other hand, the usefulness and the individual as well as societal relevance of education.

In contrast to the apparent potential, an overwhelming percentage of the investment of intellectual resources, work power, time, and money in games goes into the commercial branch leaving the branch of so-called serious games behind. Dana Massey discusses the educational potential of digital games, but points to the difficulty that "the primary function of a videogame is to make money. Any studio that seeks to make a product they feel not make money, but serve some higher ideal, best be a cooperative or charitable foundation". That the games industry is reluctant to investment into purposes such as education "is a shame, as games are the medium best equipped to do it" ([3], p. 16, p. 19). Even worse, digital games developed for educational purposes frequently fail to meet the educators' and the learners' necessities. As Egenfeldt-Nielsen put it, "edutainment started as a serious attempt to create computer games that taught children different subjects. Arguably, it ended up as a caricature of computer games and a reactionary use of learning theory" ([4], p. 42).

Massey's pessimistic look at the games industry as well as Egenfeldt-Nielsen's critical appraisal coincide with the authors' earlier experience [5,6]. This did not change much through the decade passed since then.

"It is not only for lack of trying that a good vocabulary for describing game experiences does not exist. It is downright hard to describe video games and experience of playing them" ([7], p. 22).

What was missing 10 years ago when Bruce Philips wrote down his lament cited above and what is still missing today is *a digital games science* with its own *language of discourse*. Even nowadays, we speak about digital games and game play in terms of psychology, sociology, media studies, communication network technologies, computer science, and even mathematics–a Babylonian plethora.

To find a way out, there is a need for a suitable terminology including a revised genre concept and theoretically well-based taxonomies of digital games.

The genre concept for entertainment media such as cinema is a relevant concept for not yet much more than 50 years. Applied to cinema, it works well. "Genre is about economy. By sharing a mutual language, creators and consumers agree to communicate things that would only waste valuable exposition time." ([8], p. 5) In contrast, genre is *not* an appropriate concept for scientific analysis of digital games, human game playing behavior, and the impact of game play.

The work on taxonomies of digital games and game play has several origins including, e.g., [9–13]. Among other papers, [14] is inspirational, but the Erfurt Taxonomy (a term coined in [12], section III, page 28, to go beyond the limits of the earlier Ilmenau Taxonomy) is by far more expressive. Even recent treatments (see [15], Fig. 4 on page 6) are more restricted.

2.1 Game and Play

For many reasons including commerce, there is an overwhelming amount of books about digital games (see, pars pro toto, [16,17]). Johan Huizinga's cultural-historical account [18] is an excellent starting point, but it urgently needs to be complemented by an informed approach like Raph Koster's theory of fun [19], e.g., taking the novelties of the digital age into account.

For almost a decade, a large part of the present authors' work in the area of game design, game play, and impact studies relies on a scientific position visualized by means of Fig. 1 adopted from [20,21].

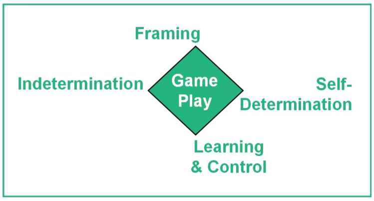

Fig. 1. Game play as a framed activity of dealing with a challenging rule-based balance.

To play means to voluntarily engage in a specific activity which constitutes an act of framing. According to the rules and mechanics of a game, players try to overcome some indetermination, may it result from randomness, from other human players, from the surrounding world, or just from complexity. Whenever humans play successfully, they gain control, i.e., they learn. *Playing is learning.*

2.2 Learning by Playing

However, the key question is *what* human players possibly learn. In front of your PC, with the game controller in your hand, or with the fingers on your tablet or smartphone, you can not learn to swim or to ride a bicycle. You can only learn *what you really do* [22].

This perspective has been frequently adopted including some recent approach to language learning characterized by the term *role-playing game-based learning* [23] (RPGBL, for short).

Richard Bartle, one of the fathers in spirit of *Dungeons and Dragons*, said that "at the persona level of immersion, the virtual world is just another place you might visit, like Sydney or Rome. Your Avatar is simply the clothing you wear when you go there. There is no more vehicle, no separate character, it's just you, in the world" (cited after [24]).

And than you act *really* in the world being *virtual*. It is the art of game design for purposes such as learning or training to wrap, so to speak, real content in an attractive virtual world. For the authors' present project, the content is German language and the player's real activity is understanding and deciding accordingly.

2.3 The Case of Static Placement Games

The future might bring so-called first-person shooters or jump 'n' run games for purposes of learning, training, and coaching, who knows! But for the time being, the authors are less ambitious and confine themselves to *static placement games*.

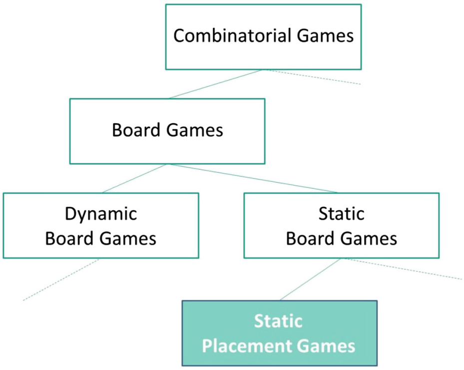

Fig. 2. Static placement games in the hierarchy of board games.

Categories of games are complex theoretical concepts which rarely have sharp borderlines. Interested readers may find, just for illustration, related discussions about so-called pervasive games for learning in [25,26] and, furthermore, about how to categorize them in [27] (in particular, Figs. 11, 12 and 13, p. 13).

Combinatorial games [28] are a wide-spread category containing sub-categories such as some pen & paper games, card games, and board games. Within the category of board games there are classical games such as CHESS, REVERSI, NINE MEN'S MORRIS and MENSCH ÄRGERE DICH NICHT, the latter one being famous in Germany developed by Josef Friedrich Schmidt in 1907/08.

Among the board games there are those with a static board. Some other games like, for illustration, LABYRINTH (Ravensburger, 1986), have a board which changes dynamically. In digital games, there occur different variations of board dynamics sometimes named *fog of war* [29]. The present focus is exclusively on static board games. But even on static boards, there may be considerable dynamics, e.g., due to certain pieces moving around. To narrow the focus further, only those games are taken into account in which the placement of pieces alone is decisive. REVERSI is a widely known example. This particularly narrow category of games is named *placement games* (see Fig. 2).

Combinatorial games, in general, are thought provoking. One may tailor them particularly to learning and training. This does still apply to the rather small sub-category of placement games.

Section 6 of the present paper is intended to survey some related recent game development project.

3 Gamification

Gamification is quite complex and rather controversial concept [30]. According to [31], "gamification is the use of game design elements in non-game contexts". It is further described and motivated as a "process of game-thinking and game mechanics to engage users and solve problems" in [32].

In many areas, it is deployed for particular purposes concerning the relationship between enterprises and customers ranging from issues of customer loyalty to employee recruitment and headhunting. Just for illustration, the web sites [33–37] offer varying programming exercises and competitions and, as Codility put it, aim at "hiring programmers made easy". [38] provides an overview of about two dozen of gamification offers on the web which are intended to make programming studies entertaining.

Most of these offers are good examples of successful gamification, because they really set up challenges which bear the potential of fun to those who engage in the game (see Sect. 2.1) and users have good chances to learn playfully, because they really exercise what they want to learn (see Sect. 2.2).

The integration of game mechanics and the transformation of content into playful elements work like an effective trigger for users to cope with an appropriate challenge that will be rewarded in the end [39].

[32,40,41] claim the game elements *points*, *levels*, *rankings*, *awards*, and *challenge* (discussed in some detail in [29]) to be the dominating aspects carried over from games to gamification applications. Although being simple, the adoption of these game elements may have a measurable impact in gamifaction applications [42].

On the other hand, there are recently mushrooming gamification approaches invoking the simple ideas mentioned above, but which apparently miss the point. Just for illustration, the web platform ResearchGate is currently trying to please its users by rewarding batches and points. As a user, one may suddenly be greeted with sayings such as "Congratulations. Your article reached 50 views", "Your co-author's conference paper reached 100 downloads", "Congratulation. Your conference paper reached 400 downloads", "Congratulation. With 147 new downloads, you were the most downloaded researcher from your institution", or "Congratulation. With 282 new publication views, you were the most viewed researcher from your institution" (all these questionable *rewards* found in one day on the second author's account). The crux is that a user is never a player who voluntarily engages in the competition. Even worse, as a user you can not do anything for scoring more points. There is no challenge and there is no fun.

The opinions about gamification are divided. Some consider already the usage of simple game elements as a case of gamification, whereas others expect some real digital game ready for play.

Although the present authors' game design (see Sect. 6) will not be very ambitious, it should allow for real play, for some challenge, and for a bit of fun.

4 Instructional Design Models for Gamification

Gamification is an apparently prosperous field of wide reach and high potential. Due to the breadth of areas in which gamification may be possibly brought to application, on the one hand, and due to the manifold of game concepts, on the other hand, one can hardly expect any universal instructional design approach fitting gamification, in general. Instead, varying instructional design theories may be more or less appropriate to application areas varying in audience, content, and context conditions.

The authors of the present paper are in a close co-operation with scientists of Friedrich Schiller University, Jena, Germany, who are engaged in teaching German as a foreign language. In particular, these colleagues provide both consultancy services and educational materials to the Goethe Institutes world-wide.

Among the subjects of this co-operation, there is the design and development of digital games aiming at a more pleasant and more effective learning of German. These digital games are in the application focus of this paper (see Sect. 6). The present section is intended to provide a firm instructional design background for these gamification projects.

Webble technology as surveyed in Sect. 5 offers suitable concepts for the gamification of textbooks as will be demonstrated in Sect. 6.

Consequently, the present investigation of instructional design issues shall be seen in the light of the technologies deployed and the applications addressed.

4.1 Benefits from Using ID-models

The main goal of most games is providing pleasure or tension to their users. Further goals are often irrelevant. On the contrary, in game-based learning and gamification approaches a clear goal is pursued, e.g. the transfer of knowledge or a certain impact on the users' behavior. Its achievement is of great importance for the success of the application. For this reason, it is helpful to apply instructional design theory to the conception of learning environments.

The authors already achieved promising results using scientific approaches in several GBL developments designed for the deployment in classrooms (cf. e.g. [43,44]) as well as in outdoor museums using augmented reality (AR) (c.f. [45]). As next step the transfer of these experiences to an eductional gamification concept (see Sect. 6) is intended.

Theoretical design models enable the best possible consideration of learning aspects. This is of great importance to the success of a gamification application. The resulting learning effects are mainly dependent on a well-founded concept that is based on *(i) a concrete goal*, *(ii) an analysis of the framework requirements*, and *(iii) design decisions*. The coordination of these three factors in combination with an analysis of the users' requirements and their goals is essential to the concept elaboration. Otherwise, the intended learning goals might be missed. Instructional design models contain helpful recommendations that can be flexibly implemented in the final concepts.

4.2 Applying the DO-ID Model

In the authors' case, the Decision Oriented Instructional Design Model (DO-ID) [46] serves as a suitable framework for the conception of gamification applications. This model has been successfully applied to former game developments like, e.g., [47].

It supports the design process and describes a hierarchical classification of the design decisions. By using the DO-ID model the process of planning and developing a multimedia learning environment can be structured and systematically justified. When planning a concept, it is important to set a specific goal and to analyze the framework requirements. The core of the DO-ID model consists of six design decisions as on display in Fig. 3 and enumerated below.

1. *format:* What kind of learning environment shall be used?
2. *content structure:* How will the content be classified and arranged?
3. *multimedia design:* Which senses shall be addressed? Which symbolic systems will be applied?
4. *interaction design:* How do the users interact with the system?
5. *motivational design:* What drives the users?
6. *graphic design:* How is the interface designed?

The DO-ID model offers a plenitude of recommendations according to the several parts of conception.

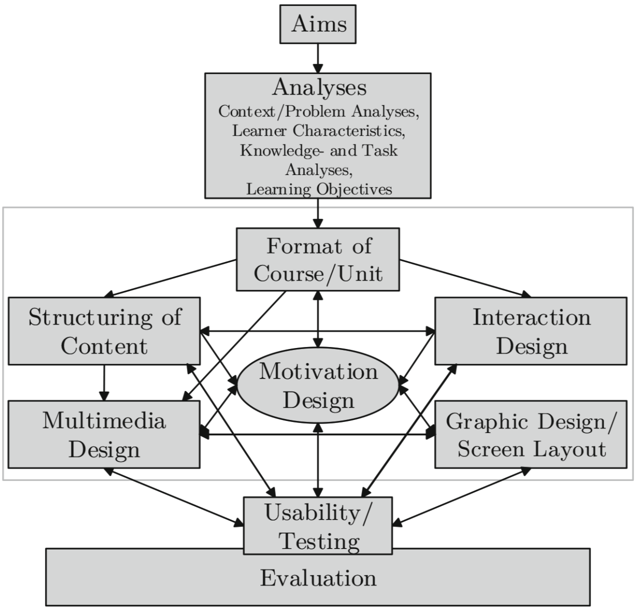

Fig. 3. DO-ID model [46] for systematization of the design process.

Therefore, it has been chosen as basis for the concepts proposed in Sect. 6. In order to roughly describe the interplay of method and technology for textbook gamification, the issue of *Structuring of Content* will be exemplified within the following paragraphs.

One aspect of structuring the content is the segmentation in appropriate units and sequencing them in a didactically reasonable way [46]. A possible solution for a German as a foreign language gamification application has already been presented in [2] where a subdivision into levels was proposed along the former textbook lessons. Besides, a structure of a possible gamification layer upon the textbook pages has been prototypically drafted that shows the arrangement of functional units on the screen. It forms a basis for *Graphic Design* decisions and, thus, is connected to the *Multimedia Design* and the *Interaction Design*. Not least, thoughtfully designed user interactions are essential to the learning process itself and also determine parts of the *Motivation Design*, especially when it comes to playful activities.

More detailed work on the content structure of the German as a foreign language application led to the question *how to realize intended learning activities by means of didactics as well as by means of an appropriate technological solution*. In the authors initial approach, a functionality is needed that enables matching semantic pairs of words. For the learners, this task will be embedded in a narrative concerning a dinner where the guests have to be seated according to several characteristics given. Seen from the structure and the mechanisms, the authors propose to clarify the category of so-called placement games (see Sect. 2 for further explanations on placement games and Sect. 6 for an overall description of the gamification concept).

Necessarily, the content structure behind must consider those characteristics and the matching seats. This information can be stored as semantic pairs in a table. As technological solution, the authors propose the implementation of building block-like elements (see *webbles* in Sect. 5) that carry the information and that can be controlled by the users, e.g. by sticking them together. Due to direct execution an appropriate system feedback will automatically be provided as soon as (mis-)matches between those building blocks are found (see Fig. 4).

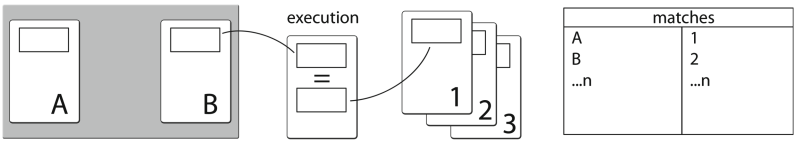

Fig. 4. Structural decisions transferred to executable building blocks.

In the following Sect. 5, webble technology will be introduced in detail which is an interface technology providing a technological solution to connect single building blocks to functional compounds.

5 Webble Technology for Gamification

Webble technology is an extremely rare case of an engineering discipline inspired by philosophical investigations. Richard Dawkins' seminal work on non-biological evolution [48] has encouraged Yuzuru Tanaka to design media likely to support the evolution of digitally represented knowledge [49]. He has coined the term *meme media*. Meme media objects considered to be digital containers, so to speak, of ideas when being in use may be subject to replication, to mutation, to cross-over and, finally, to fitness criteria.

For already half a decade, there does exist the most recent generation of meme media objects nowadays called webbles [50]. Contemporary webbles are based on HTML5, CSS, and JavaScript [51].

A variety of applications illustrate the expressiveness and the flexibility of the technology; see [52] and the contributions therein as well as the following individual papers [53–70], as well as recently [71] which cover an interesting spectrum of approaches.

To the present authors very best knowledge, webble technology, digital games, and game-based learning have been studied in their mutual interplay for the first time in [72].

A crucial feature which makes the technology appropriate for game-based learning and, in particular, for exploratory learning is *direct execution*. The term has been coined in [67]. The concept has been used for learning issues particularly in [73]. It is the driving power behind the scenes enabling learning approaches such as in [69].

Ben Shneiderman has introduced *direct manipulation* [74,75], a paradigm which has proven highly influential in software technology [76].

Seen from the purely software-technological point of view, meme media technology may be understood as a particular approach to visual programming. Building blocks of software–especially web components–are manipulated on the screen. A certain part of the sometimes tedious programming process takes place as dragging and dropping components, plugging them together for the purpose of combining functionalities (see Fig. 5 on the following page). In this way, more complex compound webbles result from plugging simpler webbles together. Under the condition that such a compound webble is functionally complete, it may run immediately. When a particular part is peeled off, completeness is lost and the computation process is interrupted. If the hole is fixed, perhaps by plugging in another component, the compound mechanism runs again.

This feature named *direct execution* in [67] allows for playful exploration of varying constructs.

The meme media objects under consideration have a model-view-controller architecture. Roughly speaking, the model determines what such a webble is doing, the view makes it accessible on the screen, and the controller is managing what the user is doing and, in this sense, is connecting the view to the model.

Compound objects consist of components which are usually visible to the human user. Each browser window on display in Fig. 5 is a compound webble. And every node of the HTML dom tree is indicating a sub-webble sitting there.

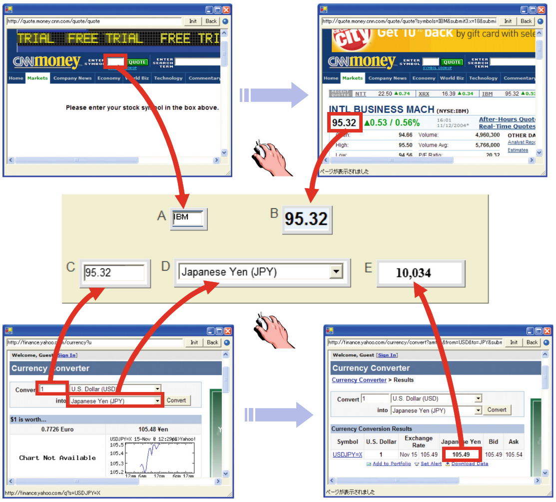

Fig. 5. Clipping components from compound webbles to construct a new web service; Fig. 10 taken from the paper [77] with kind permission of the authors.

Users may clip components from browser windows as indicated and copy them. The copies are sharing the model with their originals, i.e. they behave identically. On another webble, they are plugged together. In this particular application case, the two web services provide stock exchange prices and currency exchange rates, respectively. The combination is a new service providing stock prices in other currencies on demand. As shown, programming is performed by drag and drop.

At this point, the webbles' slot concept comes into play. Webbles have a variety of variables for the computational functionality of the model, for the appearance of the view, and for work of the controller. When webbles are plugged together, data may flow through the resulting hierarchy. Values of these variables (the variables are named slots) are propagated. The slot connections may be established by hand. In a large variety of situations it is desirable that webbles connect automatically when one webble is dragged on another one and dropped.

For the simple gamification concept addressed in the present paper, this type of auto-connection fits perfectly. Players may exploratory combine webbles and immediately experience the effect (see Sect. 6).

6 Textbook Gamification Concepts

The present section presents the authors' application development in some detail. The first subsection revisits original work from [1,2], whereas the remaining part of the section is dedicated to some novel design and development.

6.1 Gamification of Textbook Exercises

The early draft of a textbook gamification concept was based on a currently available textbook that is used for language courses in the field of *German as a* *foreign language* in adult education world-wide. The textbook "studio [21]. Das Deutschbuch. A1 (Unterrichtsmanager)" (see Fig. 6 below) represents the current state of many digitalized textbooks with quite limited interaction features: navigating, change of view, taking notes, highlighting, covering, choosing audio and video, and taking screenshots. Very often, there is no user feedback provided at all referring to the exercises to be solved.

Fig. 6. The textbook by Cornelsen publishing dealt as basis for a first concept draft.

The prototypical concept by [2] provides a first outline of the functionalities and a possible interface design of a textbook gamification application. Basically, the application is meant to be an *additional gamification mode* that can be launched upon the textbook while using it. The textbook itself remains the same. In order to adopt the didactic concept of the underlying textbook, the gamification mode makes further use of already existing textbook exercises which are transformed into mini-games. Given textbook assets are being re-used within the quests (see Fig. 7).

As classroom training with a teacher will remain one substantial factor of language learning. It is planned to use the gamification mode mainly in the leisure time for repetition or homework. It shall initiate a self-organized repetition and consolidation of skills that have been imparted during language lessons. Thus, the advantages of virtual and classroom training are combined like in blended-learning approaches [78].

During the development of the gamification concept, the DO-ID model by [46] served as framework for the instructional design. Summarizing the most relevant design decisions according to the gamification intentions leads to the following extract: Concerning the *format* a combination of content and structural gamification is recommended (cf. [2]). Game mechanics like points, rewards, ranking, and levels become necessary to provide defined goals, to enable challenge and motivation, and to give feedback on the user's progress. Regarding the *interaction design*, the controls within the application shall be simplified and made intuitive by using webbles. This might be a promising approach to further reduce the extent of cognitive load in games (cf. [43]) to a minimum for not distracting the learner from learning. The *graphic design* of the additional

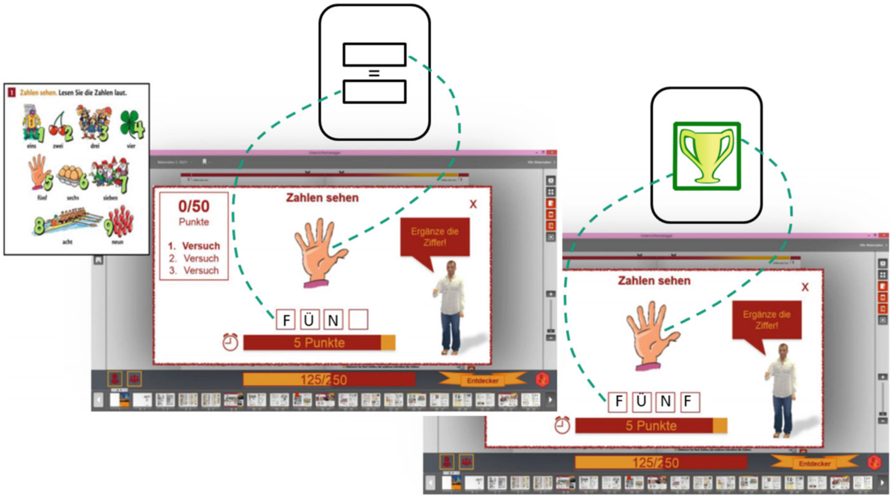

Fig. 7. The learner's input is directly processed in a webble that performs a certain matching operation and, in dependence on the outcome, delivers gratification feedback.

gamification mode requires the integration of new elements that are fitted into the existing application, but stand out from the textbook base (see Fig. 7 in comparison to Fig. 6).

The authors propose to realize the technological implementation using the concept of webble technology (see Sect. 5). The illustration above shows how the assets to be found in the textbook (e.g. the picture of a hand) are re-used and converted into functional webbles within the overlaying gamification mode (see Fig. 7). This short sequence points out the basic functioning of these web components when the user takes some action: The functionalities of single webbles are being combined. In the example, depending on the user's input, a suitable feedback (e.g. a cup as reward) will be the result of the direct execution taking place in the webble.

6.2 Competitive Playful Interactive Exercises

Within the category of combinatorial games, there exists a particularly simple sub-category of *memory games*. Some essentials of this games category have been discussed in [28] with some emphasis on generalization.

Some of these key ideas–related ideas for learning German have been used in [79]–are adopted and adapted here to be applied to placement games as introduced in Sect. 2.3, where the term *placement game* is coined.

In board games, one usually has pieces to play with. In memory games, these pieces may be called *tiles*. For the sake of comparison, this terminology is adopted subsequently.

In a memory game, players search for pairs of tiles which have identical avers or, at least, those with a *similarity* as high as possible, as suggested as a first generalization in [28].

Throughout the authors' present approach, tiles are syntactically seen as webbles (see Sect. 5). They may have numerous slots, one of them carrying the tile's avers. The basic idea is already sketched by the end of Sect. 4.2 and will be implemented by means of the technology surveyed in Sect. 5.

The board of the authors' placement game DINNER TALK consists of several cells surrounding a virtual table. In the first version of the game, there are 14 of them considered as virtual chairs. This number is of minor importance and may be changed according to experiments of game play. In addition, there are 14 tiles of the type on display in Fig. 8.

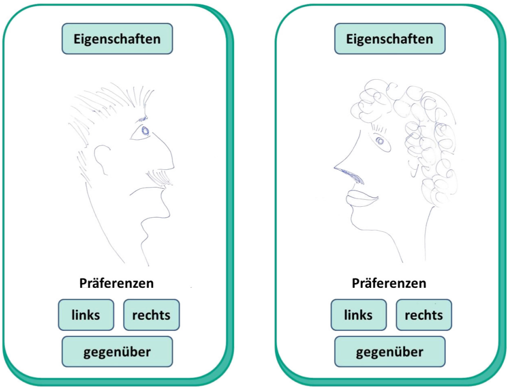

Fig. 8. Two tiles of the placement game DINNER TALK.

Tiles represent virtual characters which have properties (German: Eigenschaften) and preferences (Präferenzen). Preferences refer to communication partners at the dinner table, particularly to the left neighbor (German: links), to the right neighbor (rechts), and to the person on the opposite side of the table (gegenüber).

Tiles of the game have several slots ranging from those with a unique content (the name of the tile, e.g.) through those with possibly identical content in different tiles (gender, age, ...) to those which contain possibly longer German text fragments. Other slots which are usually hidden to the user determine the view of a webble on the screen including size and position.

There are slots which are–seen within the context of language learning– complementary to each other. These are the property slots, on the one hand, and the preference slots, on the other hand.

Human learners–when interested in playing the game–need to understand the content of pairs of complementary slots. In particular, they need to find out matches even if these matches are only partial or somehow uncertain (see the related discussion preceding Fig. 4 above).

For illustration, there is some match of the longer text in Fig. 9 "Herbert spricht gern lang und breit über Politik. Er hält die gegenwärtige Regierung für

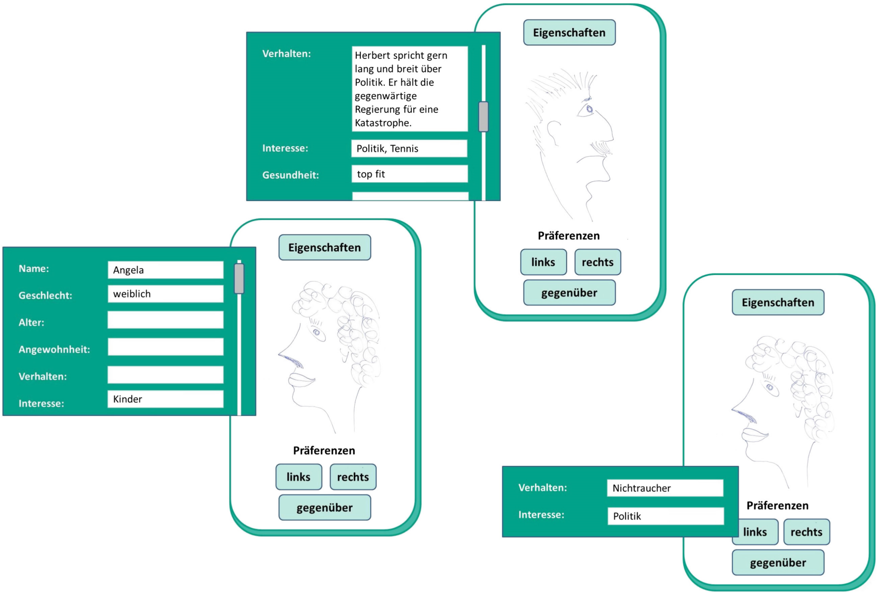

Fig. 9. Slot values representing properties (left two) and seating preferences (right).

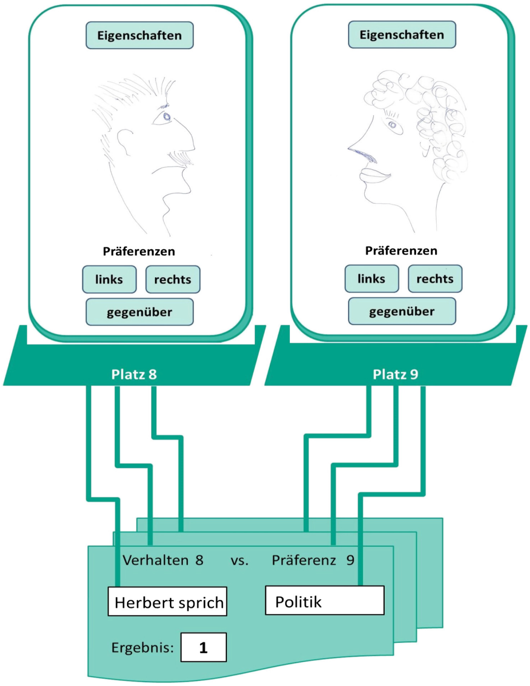

Fig. 10. Propagation of slot values from the tiles through the cells of the board to the underlying game engine webble which "knows" about the topology of the game board.

eine Katastrophe." characterizing the behavior of the virtual character named Herbert with the interest slot value "Politik" of the virtual character Angela.

From the learner's point of view, playing this digital game means seating the characters around the table. To do this appropriately, learners need to read the texts and to understand semantic relationships. Educators who design these text fragments may tune the topics considered and the complexity of the language expressions according to the learning audience.

Seen from a technological point of view, playing the game means plugging webbles into each other. More precisely, in addition to the learners' activity of inspecting slot values to read, understand, and compare German text fragments, there are only to types of moves in the game. Players may drag tiles and drop them over seats, i.e. cells of the board. To allow for exploration and revision, tiles sitting on a seat may be peeled off to be placed elsewhere more effectively.

When webbles are plugged together, slot values are propagated. The underlying game engine webble executes the matching of slot values in slots of related seats. According to the educators' similarity table of text fragments, matching values result in a positive score (the value 1 shown in Fig. 10). The game system responds to positive scores by feedback to the player. The authors' first design decision is to pop up speech bubbles for every score point.

In this way, players recognize the success of their placements. When there are no or only a very few speech bubbles, they may try other seatings. Exploration and competition is encouraged, technologically powered by direct execution.

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References

1. Baumbach, L.: Textbook-gamification: transformation von Inhalt in eine spielerische Form, eine DaF-Fallstudie. Bachelor thesis, Institute for Media and Communication Science, Ilmenau University of Technology (2015)
2. Friedemann, S., Baumbach, L., Jantke, K.P.: Textbook gamification. Transforming exercises into playful quests by using webble technology. In: Helfert, M., Restivo, M.T., Uhomoibhi, J., Zvacek, S. (eds.) Proceedings of the 7th International Conference on Computer Supported Education, CSEDU 2015, pp. 116–126, Lisbon, Portugal, May 23–25 2014. SCITEPRESS (2015)
3. Massey, D.: History through games. The escapist (29), 16–18 (2006)
4. Egenfeldt-Nielsen, S.: Educational Potential of Computer Games. Continuum Studies in Education. Continuum International Publishing Group, New York (2007)
5. Jantke, K.P.: Digital games that teach: a critical analysis. Diskussionsbeiträge 22, TUI IfMK (2006)
6. Jantke, K.P.: German girls are goofy. An investigation into the knowledge deficiencies of digital games that are designed for learning. In: Florida AI Research Society Conference, pp. 381–385. ACM (2008)
7. Philips, B.: Talking about games - a view from the trenches. Interaction **13**, 22–23 (2006)

8. Schnaars, J.: Pleasurable genres. Escapist **51**, 5–9 (2006)
9. Jantke, K.P.: Eine Taxonomie für Digitale Spiele. Diskussionsbeiträge 26, TUI IfMK (2006)
10. Jantke, K.P., Kreuzberger, G.: Aufbau einer akademischen Ausbildung für Spieletechnologie und -wissenschaft. In: Picot, A., Zahedani, S., Ziemer, A. (eds.) Spielend die Zukunft gewinnen, pp. 75–89. Springer, Heidelberg (2008)
11. Jantke, K.P.: Taxonomien für Digitale Spiele: Von Ilmenau nach Erfurt. Report KiMeRe-2009-02, Fraunhofer IDMT, Abtlg. Kindermedien (2009)
12. Jantke, K.P., Gaudl, S.: Taxonomic contributions to digital games science. In: Bradbeer, R., Ahmadi, S. (eds.) 2nd International IEEE Consumer Electronic Society Games Innovation Conference, pp. 27–34. IEEE Consumer Electronic Society, IEEE (2010)
13. Jantke, K.P., Knauf, R.: Taxonomic concepts for storyboarding digital games for learning in context. In: Helfert, M., Martins, M.J., Cordeiro, J. (eds.) 4th International Conference on Computer Supported Education (CSEDU 2012), vol. 2, pp. 401–409, 16–18 April 2012. SciTePress, Porto, Portugal (2012)
14. Sawyer, B., Smith, P.: Serious games taxonomy (2008). http://www.dmill.com
15. Laamarti, F., Eid, M., El Saddik, A.: An overview of serious games. Int. J. Comput. Games Technol., article ID 358152, 11 (2014)
16. Salen, K., Zimmerman, E.: A Rules of Play. Game Design Fundamentals. The MIT Press, Cambridge (2004)
17. Salen, K., Zimmerman, E. (eds.): The Game Design Reader. A Rules of Play Anthology. The MIT Press, Cambridge (2006)
18. Huizinga, J.: Homo Ludens. A Study of the Play Element in Culture. Beacon Press, Boston (1955). [Dutch original 1938]
19. Koster, R.: A Theory of Fun for Game Design. Paraglyph Press, Scottsdale (2005)
20. Jantke, K.P.: Knowledge media science and intelligence in digital games (Invited Keynote). In: Tanaka, Y. (ed.) Proceedings of the 4th International Symposium on Ubiquitous Knowledge Network Environment, 5-7 March 2007, Sapporo Convention Center, Sapporo, Japan, Volume of Keynote Speaker Presentations, pp. 55–61. Hokkaido University of Sapporo, Japan (2007)
21. Jantke, K.P.: Serious Games - eine kritische Analyse. In: 11. Workshop Multimedia in Bildung und Unternehmen "eLearning and Serious Games". TU Ilmenau, 20./21.09.2007, TU Ilmenau, ISSN 1436–4492 7–14 (2007)
22. Jantke, K.P., Lengyel, D.: Die Realität in virtuellen Welten. Zeitschrift für e-Learning, pp. 7–22 (2012)
23. Jantke, K.P., Hume, T.: Effective learning through meaning construction in digital role playing games. In: IEEE International Conference on Consumer Electronics (ICCE), January 2015. IEEE Consumer Electronics Society, Las Vegas, pp. 686–689 (2015)
24. Wallace, M.: In celebration of the inner rouge. Escapist **30**, 2–4 (2006)
25. Jantke, K.P., Spundflasch, S.: Understanding pervasive games for purposes of learning. In: Foley, O., Restivo, M.T., Uhomoibhi, J., Helfert, M. (eds.) Proceedings of the 5th International Conference on Computer Supported Education, CSEDU 2013, 6–8 May 2013, pp. 696–701, Aachen, Germany (2013)
26. Jantke, K. P., Spundflasch, S.: Storyboarding pervasive learning games. In: Tan, D. (ed.) Proceedings of the International Conference on Advanced Information and Communication Technology for Education (ICAICTE 2013), 20–22 September, 2013. Atlantis Press, Hainan, China (2013)

27. Arnold, O., Jantke, K.P., Spundflasch, S.: Hierarchies of pervasive games by storyboarding. In: Proceedings of the 5th International Games Innovation Conference (IGIC), pp. 8–15. IEEE Consumer Electronics Society, Vancouver, BC, Canada, 23–25 September 2013
28. Jantke, K.P.: Kombinatorische Spiele: Beiträge zur Taxonomie, Version 1.00. Technical report KiMeRe-2013-03, Fraunhofer IDMT, Abtlg. Kindermedien (2013)
29. Björg, S., Holopainen, J.: Patterns in Game Design. Charles River Media, Hingham (2005)
30. Tulloch, R.: Reconceptualising gamification: play and pedagogy. Digit. Cult. Educ. **6**, 317–333 (2014)
31. Deterding, S., Khaled, R., Nacke, L.E., Dixon, D.: Gamification: Toward a Definition. In: CHI 2011 Gamification Workshop Proceedings, Hans Bredow Institute for Media, pp. 12–15 (2011)
32. Zichermann, G., Cunningham, C.: Gamification by Design - Implementing Game Mechanics in Web and Mobile Apps. O'Reilly, Newton (2011)
33. EvalCode (2015). https://www.codeeval.com. Accessed 21 August 2015
34. Codility (2015). https://codility.com. Accessed 21 August 2015
35. HackerEarth (2015). https://www.hackerearth.com. Accessed 21 August 2015
36. LeetCode (2015). https://www.leetcode.com. Accessed 21 August 2015
37. LintCode (2015). https://www.lintcode.com. Accessed 21 August 2015
38. Schulz, H.: Wetthacken. Spielerisch Programmieren üben im Netz. c't, pp. 130–133 (2015)
39. Stampfl, N.S.: Die verspielte Gesellschaft - Gamification oder Leben im Zeitalter des Computerspiels. Heise Zeitschriften Verlag, Hannover (2012)
40. Kapp, K.M.: The Gamification of Learning and Instruction- Game-Based methods and Strategies for Training and Education. Wiley, San Francisco (2012)
41. Kapp, K.M., Blair, L., Mesch, R.: The Gamification of Learning and Instruction Fieldbook. Wiley, San Francisco (2014)
42. Blohm, I., Leimeister, J.M.: Gamification - Gestaltung IT-basierter Zusatzdienstleistungen zur Motivationsunterstützung und Verhaltungsänderung. Springer Fachmedien Wiesbaden, Wiesbaden (2013)
43. Hawlitschek, A.: Spielend lernen. Didaktisches Design digitaler Lernspiele zwischen Spielmotivation und Cognitive Load. Logos, Berlin (2013)
44. Krebs, J.: Moral dilemmas in serious games. In: Tan, D. (ed.) Proceedings of the 2013 International Conference on Advanced ICT and Education (ICAICTE 2013). AISR: Advances in Intelligent System Research, vol. 33, pp. 232–236, Atlantis Press (2013)
45. Jantke, K.P., Krebs, J., Santoso, M.: Game amusement and CRM: Castle Scharfenstein AR case study. In: 3rd Global Conference on Consumer Electronics (GCCE 2014), 7–10 October 2014, pp. 488–491. IEEE Consumer Electronics Society, Makuhari Messe, Tokyo, Japan (2014)
46. Niegemann, H.M., Domagk, S., Hessel, S., Hein, A., Hupfer, M., Zobe, A.: Kompendium multimediales Lernen. Springer, Berlin (2008)
47. Hawlitschek, A., Niegemann, H.M.: Spielend Geschichte lernen. Didaktisches Design digitaler Lernspiele. MEDIENPRODUKTION - Online Zeitschrift für Wissenschaft und. Praxis 03/2013, 15–17 (2013)
48. Dawkins, R.: The Selfish Gene. Oxford University Press, Oxford (1976)
49. Tanaka, Y.: Meme Media and Meme Market Architectures: Knowledge Media for Editing. Distributing and Managing Intellectual Resources. IEEE Press and Wiley-Interscience, New York (2003)

50. Kuwahara, M.N., Tanaka, Y.: Webble World 3.0 (2009)
51. Fujima, J.: Building a meme media platform with a JavaScript MVC framework and HTML5. In: Arnold et al., 2013b, pp. 79–89 (2013)
52. Arnold, O., Spickermann, W., Spyratos, N., Tanaka, Y. (eds.): WWS 2013. CCIS, vol. 372. Springer, Heidelberg (2013)
53. Tanaka, Y., Imataki, T.: IntelligentPad: a hypermedia system allowing functional compositions of active media objects through direct manipulations. In: IFIP Congress, pp. 541–546 (1989)
54. Tanaka, Y.: IntelligentPad as meme media and its application to multimedia databases. Inf. Softw. Technol. **38**, 201–211 (1996)
55. Ito, K., Tanaka, Y.: A visual environment for dynamic web application composition. In: Proceedings of 14th ACM Conference on Hypertext and Hypermedia, HT 2003, 26–30 August 2003, pp. 184–193. ACM Press (2003)
56. Tanaka, Y., Sugibuchi, T.: Integrated visualization framework for relational databases and web resources. In: Grieser, G., Tanaka, Y. (eds.) Dagstuhl Seminar 2004. LNCS (LNAI), vol. 3359, pp. 159–174. Springer, Heidelberg (2005)
57. Jantke, K.P., Ito, K., Dötsch, V.: Human-agent co-operation in accessing and communicating knowledge media – a case in medical therapy planning. In: Grieser, G., Tanaka, Y. (eds.) Dagstuhl Seminar 2004. LNCS (LNAI), vol. 3359, pp. 68–87. Springer, Heidelberg (2005)
58. Jantke, K.P., Kaschek, R., Nébel, I.-T.: Towards understanding meme media knowledge evolution. In: Jantke, K.P., Lunzer, A., Spyratos, N., Tanaka, Y. (eds.) Federation over the Web. LNCS (LNAI), vol. 3847, pp. 183–201. Springer, Heidelberg (2006)
59. Ohigashi, M., Guo, Z.C., Tanaka, Y.: Integration of a 2D legacy GIS, legacy simulations, and legacy databases into a 3D geographic simulation. In: Proceedings of the 24th annual ACM International Conference on Design of Communication, SIGDOC 2006, pp. 149–156. ACM, Myrtle Beach, SC, USA, New York, NY, USA (2006)
60. Ohigashi, M., Tanaka, Y.: 3D information access space based on multifacet database visualization. Syst. Comput. Japan **37**, 13–23 (2006)
61. Lamonova, N., Ito, K., Tanaka, Y.: From planning tools to intelligent assistants: [m]eme media and logic programming technologies. In: Kaschek, R.H. (ed.) Intelligent Assistent Systems. Idea Group, Hershey (2007)
62. Fujima, J.: Auto-connection mechanisms for educational virtual laboratory. In: The IET International Conference on Frontier Computing, Proceedings (DVD), pp. 396–401, Taichung, Taiwan, 4–6 August 2010
63. Kuwahara, M.N., Tanaka, Y.: Webbles: programmable and customizable meme media objects in a knowledge federation framework einvironment on the web. In: Second International Workshop on Knowledge Federation, Dubrovnik, Croatia, 3–6 October 2010
64. Fujima, J., Hawlitschek, A., Hoppe, I.: Living machinery - advantages of webble technologies for teaching and learning. In: Proceedings of 2nd International Conference on Computer Supported Education, CSEDU 2010, Valencia, Spain, 7–10 April 2010
65. Fujima, J., Hofmann, A.: On demand help systems based on webble technology. In: Verbraeck, A., Helfert, M., Cordeiro, J., Shishkov, B. (eds.) 3rd International Conference on Computer Supported Education, INSTICC, CSEDU 2011, pp. 433–436, Noordwijkerhout, The Netherlands, 6–8 May 2011

66. Guo, Z.S., Tanaka, Y.: A component-based 3D geographic simulation framework and its integration with a legacy gis. In: Kreuzberger, G., Lunzer, A., Kaschek, R.H. (eds.) Interdisciplinary Advances in Adaptive and Intelligent Assistant Systems, pp. 63–81. Hershey, IGI Global (2011)
67. Fujima, J., Jantke, K.P.: The potential of the direct execution paradigm: Toward the exploitation of media technologies for exploratory learning of abstract content. In: eLBa 2012, pp. 33–42 (2012)
68. Jantke, K.P., Fujima, J., Schäfer, C., Spickermann, W.: Computer-aided cutting-edge research on history for home edutainment and exploratory learning. In: The 1st IEEE Global Conference on Consumer Electronics, GCCE 2012, pp. 73–74. IEEE, Makuhari Messe, Tokyo, Japan, 2–5 October 2012
69. Arnold, O., Fujima, J., Jantke, K.P., Tanaka, Y.: Exploring and understanding the abstract by direct manipulation of the concrete. In: Helfert, M., Martins, M.J., Cordeiro, J. (eds.) 4th International Conference on Computer Supported Education (CSEDU 2012), vol. 2, pp. 100–107. SciTePress (2012), Porto, Portugal, 16–18 April 2012
70. Fujima, J., Jantke, K.P., Arnold, O.: Media multiplicity at your fingertips: Direct manipulation based on webbles. In: Proceedings of the 2012 IEEE International Conference on Multimedia and Expo Workshops, pp. 217–222. IEEE (2012)
71. Jantke, K.P., Fujima, J.: Generic technologies for serendipity: toward far-reaching and effective participation in an e-society. In: e-Society 2015, Madeira, (March 2015, to appear)
72. Jantke, K.P.: Digital game knowledge media (Invited Keynote). In: Tanaka, Y. (ed.) Proceedings of the 3rd International Symposium on Ubiquitous Knowledge Network Environment, 27 February–1 March 2006, Sapporo Convention Center, Sapporo, Japan, Volume of Keynote Speaker Presentations, pp. 53–83. Hokkaido University of Sapporo, Japan (2006)
73. Jantke, K.P.: Direct execution learning technology. In: Arnold et al., 2013, pp. 90–109 (2013)
74. Shneiderman, B.: The future of interactive systems and the emergence of direct manipulation. Behav. Inf. Technol. **1**, 237–256 (1982)
75. Shneiderman, B.: Direct manipulation: a step beyond programming languages. IEEE Comput. **16**, 57–69 (1983)
76. Hutchins, E.L., Hollan, J.D., Norman, D.A.: Direct manipulation interfaces. Hum.-Comput. Interact. **1**, 311–338 (1985)
77. Tanaka, Y., Ito, K., Fujima, J.: Meme media for clipping and combining web resources. World Wide Web **6**, 117–142 (2006)
78. Mandl, H., Kopp, B.: Blended Learning - Forschungsfragen und Perspektiven. Forschungsbericht Nr. 182 der LMU München, Department Psychologie, Institut für Pädagogische Psychologie (2006)
79. Sanchéz, J., Sanz, C., Dreke, M.: Spielend Deutsch lernen. Interaktive Arbeitsblätter ffür Anfänger und Fortgeschrittene. Langenscheidt, Berlin (1997)

Teacher Technology Use: An Interplay of Learning Preference, Teaching Philosophy, and Perception of Technology

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Abstract. Teacher technology use is a key element in the successful teaching and learning of STEM (science, technology, engineering, and mathematics) courses. However, even with the increasing availability and number of new technologies and hi-tech learning environments, teachers don't always integrate technology into their teaching practice in a meaningful way. Over the three-year period of this case study, we followed the experiences of two high school teachers working in a depressed urban setting as they began using a newly constructed, innovative, high-tech STEM classroom. Using a grounded theory approach, we analyzed data from a series of semi-structured interviews and classroom observations. Three themes related to the teachers' technology use emerged: personal learning preference, teaching philosophy, and perception of technology. We explore these themes, propose a model that illustrates their relationship, and suggest areas of future research. These findings will be beneficial to anyone seeking to facilitate the meaningful adoption and use of technology by teachers.

Keywords: Technology · Teachers · STEM · Secondary education · Teaching philosophy · Teacher learning preferences · Teacher perceptions of technology · Teacher beliefs · Autonomy · Model

1 Introduction

Researchers have identified a variety of factors that influence the successful introduction of technology into a teaching setting. These factors include both internal and external factors. External factors include access to technology, sufficient training, technical and administrative support, and the environment and culture of the educational setting, while internal factors include but are not limited to a teacher's self-efficacy, attitude about technology, and openness to change [1–5]. The interaction of these factors is complex, and plays an important role in determining the extent and ways that technologies are used within a setting. Each day, when teachers enter their classrooms, they bring with them a variety of unique experiences and backgrounds, skills, and attitudes about technologies and education [6], and these elements have the potential to impact a teacher's understanding of the benefits and limitations of using technologies in teaching [7]. This paper reports the findings of a three-year case study in which we followed two

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teachers' experiences teaching in an innovative, technology-rich Science, Technology, Engineering and Mathematics (STEM) classroom. Our intent was to identify and understand factors influencing these teachers' decisions on whether and how to use the new technologies in their teaching, as well as explore any subsequent changes in their teaching practice.

Technology use in the classroom has been connected to both increased interest in and engagement in STEM activities, leading to improved STEM teaching and learning; thus, the meaningful adoption of technology by STEM teachers is viewed as essential to student success in STEM [8]. Technology-based lessons are often perceived as more authentic, giving students opportunities to engage in real-world STEM activities and experience using equipment similar to that which real STEM professionals might use [9]. Unfortunately, there is disparity in the availability of and access to technologies needed to teach STEM, as schools in low-income communities do not always have the materials, laboratories, and equipment to teach these subjects effectively [10, 11]. In fact, in a recent Pew Research Center report [12], 56 % of teachers of the lowest income students indicated that a lack of resources among students to access digital technologies is a "major challenge" to incorporating more technology into their teaching.

Additionally, even in schools where technology is readily available, the meaningful adoption of technology by teachers can still be problematic. While having sufficient and up-to-date resources available is important for STEM teaching and learning, access to resources in itself does not guarantee improved student outcomes. Even when technology is used in instruction, it is often not truly employed in transformative or innovative ways, but merely mimics what has always been done in the traditional classroom. In a study involving over 1,000 students, Wang et al. [13] found that the majority of students reported using computers in a school setting primarily for word processing and Internet searches, not for problem solving or creative activities. Although several research studies have identified possible reasons for this ineffective use of technology by teachers (e.g., lack of time, insufficient training, lack of confidence, technical issues, etc.) [3, 13–16], there appears to be no significant improvement in the situation [12].

If teachers are to successfully adopt new technologies, Ertmer and Ottenbreit-Leftwich [17] suggest that they need to change their mindsets to accept the idea that "effective teaching requires effective technology use" (p. 256). However, change, whether in mindset or practice, is not easy. The experiences and beliefs that teachers bring to the classroom have a major impact on instructional practices and willingness to change those practices since new experiences are filtered through teachers' existing beliefs and experiences [6, 17, 18]. One strategy that has proven successful in modifying teachers' beliefs and increasing their confidence and self-efficacy when teaching with technology is to encourage them to make small changes when teaching with technology before attempting major changes. Thus, when innovations are introduced into an educational setting, teachers will require time and support before the innovations can be adopted and implemented to any substantial degree [19].

In a seminal paper, Becker and Ravitz [20], investigated how teachers reported that technology use changed their pedagogy with specific emphasis on the adoption of constructivist practices in technologically rich settings Based on their study of practicing teachers, the researchers found a high correlation between use of the technology and the range of self-reported changes in teaching particularly among secondary science and social studies teachers. They further reported that the longer the teachers used technology in the classroom, the more their pedagogy changed. Time and experiences appear to play important roles in the adoption of new technologies.

The three-year study described in this paper is an attempt to understand how and to what extent change occurs in a particular classroom setting given an influx of innovative technologies for teaching and learning STEM. We were guided by two broad questions: What factors influence the ways and the extent that a teacher uses the newly available technologies when teaching in a high-tech STEM classroom? How does the availability and use of the new technologies change teaching practices?

2 Method

In seeking to understand the complex interplay of factors involved in teacher and technology use, we used a qualitative case-study design. This design enabled us to acquire and interpret data from multiple perspectives within the natural setting [21, 22] and to “describe the unit of study in depth and detail, in context and holistically” [21, p. 54]. The variety and detail of data allowed us to create a rich story of the participants and their experiences over the course of the study.

2.1 Setting

McCloud High School (pseudonym), the setting for this study, is an underperforming public secondary school located in a U.S. city in a large metropolitan area. According to 2013 data, 97 % of the residents of the city are African American with 41 % of households classified as being below the poverty level. In June 2014, the unemployment rate in the city was 13 %.

McCloud High School has been in existence for approximately 17 years. During the 3 years of the study, the school averaged 110 students all of whom were African American and between the ages of 13 and 19 years. The school employs three full-time STEM teachers and offers a range of STEM courses, requiring students to successfully complete 3 years of mathematics and 3 years of science in order to graduate. In 2012, the school began to introduce courses from a pre-engineering program, Project Lead the Way (PLTW), into the curriculum.

In 2011, the school received a major gift for construction of a classroom containing a variety of innovative technologies, including 3D printer, video wall, robotics kits, humanoid robot, graphing calculators, iPads, and high-definition video conferencing. This STEM classroom was designed with teacher and student input, along with guidance from the director of a nearby university’s STEM Center, to be a flexible, high-tech learning space that fosters collaboration and creativity [23]. The classroom and its technologies represented an educational innovation with the potential to catalyze major changes in teaching practice. Prior to construction of the STEM classroom, the school had access to two outdated computer labs that often were not fully operational. Most of the school’s traditional classrooms have a projector and teacher laptop, and a few of the classrooms have been equipped with SMART boards.

The study began with the initial planning for the STEM classroom in late spring of 2011 and ended in the summer of 2014. Both of us who served as researchers for this study are researchers affiliated with the university's STEM Center. We conducted all data gathering and analysis. In our role as researchers, we attended meetings and other events associated with the school and the new classroom (e.g., visits to high-tech schools, STEM classroom open house, monthly STEM staff meetings) in order to better understand the environment. We also supported logistical aspects of the classroom's implementation, often helping to coordinate events between the high school and the university or other external groups, and so had regular opportunities to interact with the participants.

2.2 Participants

We chose our two participants purposefully in order to obtain the most meaningful, relevant, and detailed information possible. Both Ms. Beech and Mr. Aspen (pseudonyms) were full-time STEM teachers employed at McCloud throughout the entire time of the study and have been closely involved with the STEM classroom from its early design through its final implementation. Additionally, both teachers attended project-planning meetings for the new classroom, providing valuable input to the design team on the room's layout, furniture, and technology. They also made several visits to high-tech schools and participated in technology-focused professional development. They began teaching in the room as soon as its construction was complete and continued to teach in the room throughout the study, giving feedback on their experience to the project partners at regular monthly meetings. Their continuous, close involvement with almost all aspects of the STEM classroom made them ideal sources of information regarding its impact on teaching practice at the school.

Ms. Beech is an African-American female in her sixties. At the time the research study was initiated, she had been teaching science and math at McCloud High School for 4 years. She had previously taught science for 2 years immediately after graduating from college in the late 1960s, but then entered the business world as an IT professional. She reported having a very satisfying career, saying "I really, really enjoyed IT in my day. There was such a joy in designing and building systems and making them work." She retired from this work after 37 years, during which time she filled many roles from programmer to analyst to manager and also earned a master's degree in business administration (MBA). After retirement from her IT position, she returned to school to earn a master's degree in teaching science. She continues to increase her knowledge and skills as a teacher by participating in a local university's professional development program designed to improve science teaching and student learning. During the time of this study, she taught a variety of courses including biology, chemistry, physics, pre-calculus and anatomy. She also participated in summer workshops to prepare her to teach an introductory PLTW course. Ms. Beech believes it is her responsibility to share with her students what she has learned: "I took all those courses … and so it would be a sin not to give them everything I got." Her teaching style involves a lot of interaction with the students and checking individual students' understanding of concepts: "[I want] to know what each individual is doing as opposed to one or two people…I talk to them all the time. I'm a living and breathing example of 'this is what you do in life.'" She believes that in addition to helping students get "a better, deeper understanding of the concepts," she has an important responsibility to help students learn to use what they already know, to think creatively, and to acquire "habits that will help them get through" life.

Mr. Aspen is a Caucasian male in his twenties. When the research study began, Mr. Aspen was in his first year of teaching after having completed a bachelor's degree in biology and a master's of arts degree in teaching science (MAT). He became familiar with McCloud High School through his time as a student teacher there. His teaching responsibilities included algebra, geometry, general science, and introduction to engineering. In addition, he assisted with the school's robotics team and a university-sponsored game design club. Mr. Aspen is very comfortable with a range of technologies. As he approached his fourth year teaching, he decided to enroll in an online master's program in computer science because of his interest in technology and the flexibility such a program offers. Mr. Aspen described mastering more "problem solving skills" as one of the main goals he has for his students. He added: "[I want them] to be able to do a lot of different things pretty well or come up with different answers rather than be able to do [one thing] like integrals or quotients really well."

2.3 Data Collection and Analysis

Primary data sources included a series of semi-structured interviews and direct observations in both the traditional and STEM classrooms. Interviewing began during the design of the room so as to get an understanding of each teacher's background and their experience teaching in their regular classroom. Over the course of the study, we conducted three hour-long interviews with each participant as well as a final 'participant check' interview. The initial interview protocol included questions on the participants' education and teaching history, use of technology, and classroom environment. Subsequent interviews were more open, allowing for the flexibility to pursue emerging themes and issues.

Observations began early in the project, again to get a sense of the teachers' experiences in the context of their regular classroom. Later, after completion of the classroom, participants were observed in both the STEM classroom and a regular classroom. When possible, we observed the same class taught in both the traditional and the STEM classrooms. Together, we observed each teacher numerous times, giving us direct experience with the school setting plus the opportunity to notice things that might otherwise seem routine (and therefore go unmentioned) by the participants [21].

As with any qualitative study, data analysis began and overlapped with data collection. We used NVivo software to facilitate the analysis, but also coded much of the data manually. Field notes were taken by hand. Interviews were audio recorded, then transcribed by one of us or by a graduate student assistant. Although we always interviewed and observed our participants together, we coded the transcribed data independently, using a constant comparative process as described by Corbin and Strauss [24]. We began with open coding–reading through transcripts and looking for meaningful units of data. These units of data were then grouped into categories. The development of these categories–or themes–was guided by our research questions as well as by patterns that emerged. As categories arose, they were constantly refined as more data was collected and analyzed. Then, for each category, we developed and defined its properties and dimensions, allowing us to "differentiate a category from other categories and give it precision" [25, p. 117]. Properties are particular attributes of a category; dimensions delineate a continuum along which a property can be located. For example, participants discussed aspects of their *personal learning preference* (category), which had an attribute of control of learning or *locus of control* (property). However, this property can vary from completely self-directed or *internal* to completely other-directed or *external*. Then, we located each participant along each dimension's continuum, allowing us to discern important characteristics about the participants and to make comparisons between them. This grounded theory approach to analysis kept us focused on the data, helping us to form well-developed categories while keeping a lookout for newly emerging ideas.

To increase the credibility of our findings, we used several types of triangulation–multiple methods, multiple sources of data, and multiple investigators [26]. Interview and observational data supported and were used to check each other. Additionally, member checking helped to ensure credibility. Each interview was an opportunity to clarify and expand upon the developing themes; and during the final interview, we asked each participant specifically to comment on our interpretation of their previous interview responses and their classroom activities. Our aim was to build in triangulation throughout the study, weaving together data collection, analysis, and verification [27].

3 Results

We found that the teachers' use of technology reflected an interweaving of their beliefs about teaching and technology with their personal learning preferences and accumulated life experiences. In this section, we present three categories (or themes) that emerged from the data analysis and represent aspects of this intricate relationship between teacher and technology use. For each theme, we briefly define it and then discuss it in terms of its framework of properties and dimensions (Table 1), using participants' quotes as further illustration.

3.1 Personal Learning Preference

One theme that emerged was personal learning preference. We defined personal learning preference as the teacher's self-described way that she or he learns best, both in and out of formal settings. Outside formal settings, learning may be pursued because of personal interest or belief that what is learned might be of use personally or professionally. The learner determines the pace and setting as well as what and how learning occurs. In contrast, formal settings involve planned learning in which someone other than the learner structures the learning goals, environment, content and process. Each teacher gave various examples of how they learned in both types of settings, with both teachers speaking of learning independently. For example, Mr. Aspen described how he would learn to use new software: "I would just look online until I found something that would be a nice tutorial." Ms. Beech was similarly independent: "I spread out at my kitchen table, I take a book, and I go at it." The teachers also emphasized the personal nature of learning and the need to "own" one's learning. Ms. Beech explained, "In my mind, it seems to me that learning is a personal thing. People can guide you as best they can but individually you have to make it your own." Mr. Aspen also felt that individuals needed to personalize their own learning: "I think it's really important that they learn what works for them." Both teachers saw the control of and responsibility for learning residing internally, within the learner, allowing individuals to make choices about when and how they learned.

However, despite agreeing on the importance of learner responsibility and independence, there were some basic differences in their personal methods for learning. Mr. Aspen described a technology-oriented and multi-method process:

> My hierarchy is written tutorial, picture-based tutorial, video tutorial. So I would probably start working my way down until I found what I wanted. I've never been able to sit through a lecture and take notes and then understand what's going on by those notes. I have to do multiple things.

In contrast, Ms. Beech described her preference for traditional, written materials and a more focused approach: "I used to love reading IBM manuals, God in heaven, I longed for it, I did, because you could read it and you could understand." She also shared her dislike of online tutorials and "help" options with "snippets of this and snippets of that," describing them as "appalling." For both teachers, the ability to choose how they organized their learning (internal locus of control) was important, but the actual organization varied significantly, with one being more structured and the other being more freeform.

There were also differences in the physical learning environment preferred by each teacher. Ms. Beech described needing quiet, more controlled surroundings: "Sometimes things will pop off the page, and so you need to stop and ponder it. I don't learn in chaos." In contrast, Mr. Aspen described a more chaotic learning environment: "I do all my work sitting on the couch at the coffee table with a dog running between my legs and [the] TV on." So, again, the teachers acknowledged the importance of having internal control over their learning environment, choosing the atmosphere that suited them best. One teacher preferred a very calm and structured atmosphere, while the other was comfortable studying in a more disordered setting.

Table 1. Categories (factors) and their properties and dimensions.

Category	Property	Dimension
Personal learning preference	Locus of control	External - Internal
	Locus of responsibility	External - Internal
	Organization	Freeform - Structured
	Atmosphere	Calm - Chaotic
Teaching philosophy	Role of teacher	Lecturer - Facilitator
	Role of student	Passive - Active
Perception of technology	Personal value	Practical - Entertaining
	Educational value	Narrowing - Expanding
	Impact on teaching	Restricting - Enhancing

Finally, we noted that the teachers' learning preferences also showed up in their opinions of professional training. Neither teacher is a fan of traditional professional development, particularly for learning about technologies. Mr. Aspen preferred to 'tinker' rather than participate in formal training on how to use technology tools. Ms. Beech described her frustration with the rapid pace of professional development on technologies:

> You've got some of the worst training, in my opinion, because people who run the seminar will say 'do this, do this, do this' and you want to say 'for real?' And then you're supposed to be expert in that.

The traditional professional development format, with its tendency to have a more external locus of control, didn't meet their desire to be in control of their own learning (i.e., to choose when and how to learn). They had a need for autonomy and to learn in an environment with which they were comfortable.

3.2 Teaching Philosophy

A second theme concerned each teacher's personal teaching philosophy. We defined this as the teacher's personal beliefs about how teaching and learning occur combined with examples of how the teacher puts these beliefs into practice when teaching. Both teachers spoke at length about what should happen in the classroom and what they did to optimize teaching and learning. Both valued direct interaction between teacher and students, usually in the form of meaningful discussion or dialogue surrounding questions or problems. Ms. Beech acknowledged that she did a lot of talking when teaching, but not as lecture: "My teaching style is probably to talk, but talk with the students. I like interacting with them, I just do. You've got to stop, pause, and discuss." Mr. Aspen saw interaction as an opportunity for questions: "I want some dialogue with students along the way, allowing students to ask more questions."

Often, the purpose of this dialogue was to assess a student's level of understanding and to elicit a student's thinking processes, making them visible to both teacher and student. Ms. Beech's approach to teaching very much emphasized this:

> You've got to talk about what got written so that the teacher can be assured that the students are getting where they need to be. I need to know what they know. We could be going on and on, and I'm thinking that things have been communicated and are well understood. Then you start talking to 'em and you realize that that whole boat was missed! So those are opportunities that you get to find out where they are. For me, it takes interaction because the room is full and you got people at different levels of interest and different levels of preparedness.

Although more teacher-centered in appearance, her role in the class discussion was very purposeful, and she did not see herself as a lecturer.

When observing teaching sessions, whether in the STEM classroom or the traditional classroom, we saw Ms. Beech continually using questioning to engage with students (teacher asking students, students asking teacher) with lots of give and take occurring between the teacher and the students. Through her interactive style, she made sure all students were included and accountable for what was being taught. Similarly, Mr. Aspen stated: "Asking more questions to figure out where we need to go is a lot of how I am." Both teachers felt that students should be actively engaged in the classroom activities and in their learning.

Additionally, each teacher saw their role as one of facilitator or guide, providing critical structure and direction to the students' learning experiences. Ms. Beech referred to one of her classes as "more of a seminar type thing," with her guiding class discussion to elicit student thinking and assess student understanding:

> We do a lot of conversing, and I really like the physics class because we can sit and talk about things and they [the students] really are good at sharing their thoughts and questioning what someone else has done. They're freer to just say, "um, I don't think you're right there," and then talk about it. I really like that kind of thing. They will even do that among themselves and do it politely, and that's really a good thing.

Utilizing a slightly different type of guidance with his students, Mr. Aspen specifically referred to himself as a facilitator and coach:

> I want to be engaged with them, have them be the primary speakers and me be a facilitator of education rather than an expert of education. What's been helping me through a lot of things and helping a lot of the students through is providing set and clear, established expectations for what they need to do. Today I wrote what you need to do to get every bit of points right on that board (points to board in front of classroom) at the beginning of class, showing them, okay, this is what we are going to be doing, more of a learning coach than a knowledge giver.

For both teachers, meaningful classroom interaction was the key to successful teaching and learning.

Interestingly, Mr. Aspen's philosophy evolved somewhat during the period of the study, changing from unsure and idealistic to more confident and realistic. During our final interview, he described this shift in his teaching:

> I am teaching differently than I used to because it used to be a very binary system. I was really way too far on the progressive side, or I was way too far on the traditional side. I tried to do something, and if it didn't work out like I wanted it to, I would fall back to this 'lecture and do problems from a worksheet' sort of thing.

As an early-career teacher, Mr. Aspen was still finding the best way to meld the ideals of his teaching philosophy with the realities of the classroom.

Teaching philosophies tend to evolve with experience and over time. Dexter et al. [7] attributed the evolution of teaching philosophy to a teacher's experiences in the classroom, and reflection on those experiences combined with the professional culture of the school. During the 3 years of the study, we saw changes in the way Mr. Aspen taught, which he attributed to moving from being a novice teacher to a more experienced teacher and to reflecting on the outcomes as he tried different teaching approaches. Early in his first year of teaching, Mr. Aspen stressed: "I am very much not a traditional style teacher. I have found it a lot easier to put the work on students rather than me." However, following his third year of teaching, he admitted that his philosophy had changed:

> I am no longer under the assumption that I can change education for kids overnight… I've actually gotten more traditional. I wouldn't say that I am a traditional teacher, though. I think I lecture more and introduce concepts more at the beginning of class than I used to because I found that kids are more familiar with that [approach] and receptive to it and so I try to pick out

> specific concepts that, if I know they're going to run into this problem within the first five to ten minutes of them working with something, then I try to address it up front.

Thus, as Mr. Aspen gained teaching experience, he began to think differently about what works best in the classroom and to make small modifications to his teaching practice in both classrooms.

3.3 Perception of Technology

A third theme concerned each teacher's perception of technology. We defined this as the way a teacher views and uses technology, both personally and professionally. Both teachers viewed technology as a tool, something that could be potentially useful in and out of the classroom. Each teacher spoke of the many practical advantages to using technology. Mr. Aspen believed that knowing how to use technology is essential in today's world. He considered himself tech-savvy, regularly using the Internet and technology gadgets in his daily life, and is a self-proclaimed 'geek.' Ms. Beech also valued technology, but emphasized its more practical uses:

> I really do appreciate cell phones because there are a lot of needs in an emergency. I used to have to write things by hand, and when I started [working] it was punch cards. Then it evolved… so technology, in that sense, is a good thing, and it really has helped the countries of the world. I think you get so much productivity with technology.

For Ms. Beech, technology's value resided more in its impact on safety and efficiency and less in its potential for entertainment and education.

In addition to personal entertainment, Mr. Aspen described how technology helped him to be more productive, adaptable, and flexible in his classroom:

> I was going to have an end of year survey for my students and get feedback from them, and I was actually able to just say, 'Okay, everyone go get an iPad.' I was able to make a Google form in the time that it took them to go get that and come back, and I just did it that way. It's nice to have that adaptability. A lot about it [technology] is the flexibility that you have. If I need some kids to just swing over and start working on something online, or on a computer, or a quick self-check quiz, or a Kahn Academy lesson or something like that, it's really nice to have the flexibility to do that.

Technology expanded his options in the classroom and enhanced his teaching.

While Mr. Aspen embraced the use of technology in teaching, Ms. Beech questioned its role in teaching and stressed that she will not use it "just for the sake of using it." She worried that technology has been too widely and too quickly accepted:

> I get the sense that there's a lot of looking outside of current resources to access a lot of stuff that apparently is effective. I think technology is a good thing. I have not bought into technology being a replacement for [the] teacher; I just haven't bought into that it replaces interaction with students. I really don't want to imply that that's a general perspective on technology, but with the constant hype about using technology, I think that you're left with the impression that if you're not using technology, then there's definitely something wrong with you. I think that if the teachers work at it, and if the technology can facilitate more learning in some way, then it'll be a good thing.

While Ms. Beech questioned the use of technology in teaching, she was aware that, with effort, it could be used effectively. The main drawback in learning to use technology effectively in the classroom, according to Ms. Beech, was the time it required to find good resources that could be integrated in a way that promoted student learning. She viewed technology as limiting student learning:

> What happens, I think, is that when you rely too much on technology, kids will learn a pattern and they will not understand the pattern; they cannot transfer it. So what I need to know is how much technology do we get that actually focuses on the ability to transfer?

While she perceived technology as potentially narrowing students' learning experiences, she also sensed that with time and effort teachers could make the difference and ensure that technology facilitated learning.

4 Discussion

The results of this study highlight the impact that teachers' experiences, beliefs, and perceptions have on their use of technology. Both teachers in this study were presented with a new and very unusual teaching environment: a high-tech STEM classroom designed for flexibility. In addition to this new room, the teachers were provided with a technology support specialist, customized professional development, and the support of the school's administration, as a lack of these items has been identified as a major factor influencing teachers' adoption of technology [3, 14, 28]. Both teachers made use of this environment, bringing their students into the STEM classroom on a regular basis and using its new technologies. Over the course of 3 years, as the teachers became familiar with the innovations, we noticed small changes in how they used technology in their classroom teaching. For example, Ms. Beech had students teach the class about using graphing calculators, incorporating some peer instruction into her normally teacher-centered classroom. Becker and Ravitz [20] found that a major change reported by teachers when using technology was willingness to "let go" and allow students to assist in teaching about technologies with which they were not familiar. Ms. Beech may have been taking a first step in that direction. Meanwhile Mr. Aspen, initially allowing his students to explore with technology as much as possible, incorporated more direct instruction into his class by the end of the study, stating that technology needed to serve him and not the other way around. This change may be a combination of his experience with the STEM classroom's technologies and his gain in years of teaching experience, moving from novice teacher to expert.

Nevertheless, despite these modest changes, we did not observe any significant change in the way technology was used by either teacher or in the overall way that they taught. Each remained true to their own core beliefs and viewpoints—beliefs and viewpoints that lie at the heart of their teaching philosophies and their perceptions of technology, and that appeared to be largely shaped by their life experience and personal learning experiences. Research by Ertmer et al. [29] supports this alignment between personal beliefs and technology integration. On the other hand, our findings contrast with those reported by Becker and Ravitz [20] who found a strong relationship between technology use and pedagogical change among secondary science teachers; however while these researchers described a causal relationship between technology use and pedagogical change, they questioned whether this underlying relationship is limited to teachers who already were inclined to teach in a constructivist manner.

Several other researchers have studied the effect that teachers' beliefs have on their teaching behaviors and their adoption of innovations [4, 9, 30, 31]. For example, in a study of factors influencing adoption of inquiry learning curriculum in science, Roehrig et al. [18] reported that teachers' beliefs combined with school support played an important role in how a new science curriculum was implemented. Furthermore, teachers' practices and beliefs are formed based on various aspects of the teacher's background, including professional background, content and pedagogical knowledge, knowledge of technology, beliefs about teaching, classroom activities, classroom and school level environments, the teacher's technology self-efficacy, and professional activities [5, 6, 32]. Our findings are consistent with results of these studies and contribute to the international literature on factors influencing teachers' use of technologies [1, 3, 6, 33].

The three themes that emerged from the data create an interrelated set of factors that directly and indirectly influenced the teachers' use of technologies (Fig. 1). The first theme, the teachers' personal learning preferences, directly influenced both teaching philosophy and perception of technology and thus indirectly guided their use of technologies in teaching. As self-described independent learners, the teachers encouraged their students to be the same, to ask and pursue their own questions and take responsibility for their own learning. Often, as in the case of Mr. Aspen, this independence showed up in the differentiation that was built into the lessons, allowing students to work at their own pace and on their own projects using the technology of their choosing when possible. Ms. Beech expected her students to go beyond what was covered in class and to work independently to learn more on their own time. Both teachers held the strong belief that students have to "make learning their own." No matter what happens in the classroom, the responsibility and control of learning resides within each student. This strong internal locus of control and responsibility made up a large part of both teachers' personal learning preferences, and in turn, formed a significant part of their teaching philosophy and impacted their perception of technology. By the end of the study, it was evident that both teachers teach with technology according to their own teaching philosophy and perception of technology, which were strongly influenced by the way they preferred to learn.

The second theme, teaching philosophy, is strongly tied to what teachers believe to be best in education, including their beliefs about effective pedagogies. We observed elements of each teacher's teaching philosophy directly impacting their use of technology in both the traditional and STEM classrooms. For example, each teacher believed in the importance of verbally interacting with students–not lecturing them, but talking *with* them. Neither teacher saw him or herself as a traditional lecturer; talking was used very purposefully to elicit student thinking and to gauge student understanding. Mr. Aspen regularly took advantage of the numerous projection options in the new STEM classroom to display individual student work on computers and engage students in discussion about that work. Even Ms. Beech, who considered herself more of a knowledge giver than facilitator, expected her students to take an active role in their learning. When she began using PowerPoint slides in classes, she used them as a basis for class discussion. Both teachers encouraged students to ask questions, listen carefully, and thoughtfully discuss the material. They valued student-student interaction as well as student-teacher interaction, and both teachers expected their students to become critical thinkers and independent learners. Even though the teaching environment changed and technologies were introduced into it, the philosophy of teaching still guided teaching practice and was a primary influence on their use of technologies. Stephen [35] found a similar relationship between teaching philosophy and how and when teacher-designed lessons incorporated technology.

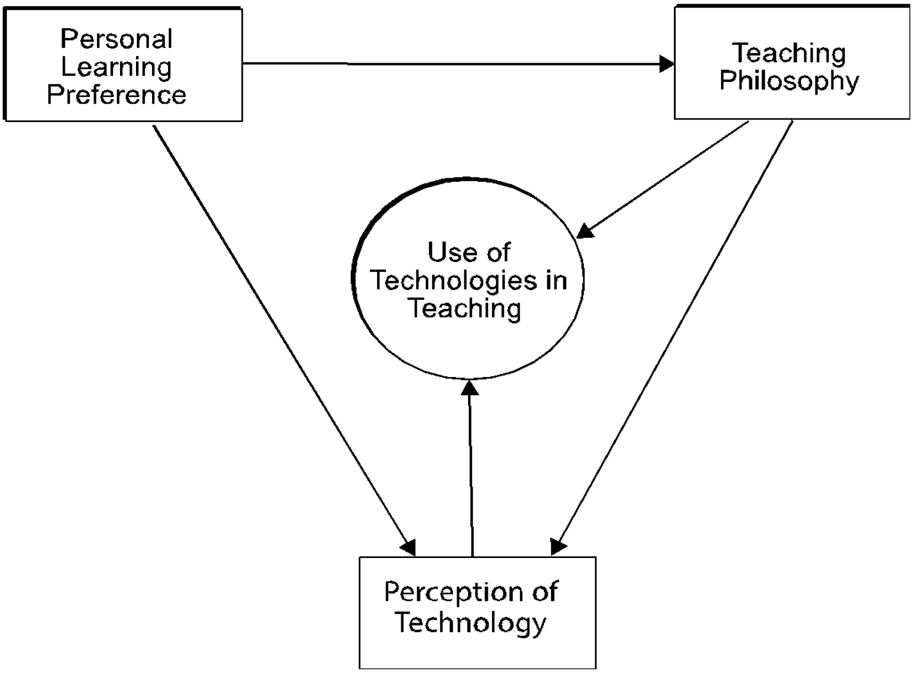

Fig. 1. Relationships among factors influencing teachers' use of technologies.

Since the new STEM classroom was equipped with a variety of new technologies, it is not surprising that the teachers' perception of technology emerged as a prominent theme in our analysis, directly influencing the classroom use of technologies and, at the same time, being directly influenced by both the teacher's personal learning preference and teaching philosophy. Other researchers have identified the influence of teachers' beliefs about and perceptions of technology on their decisions on when and how to use technology in teaching [33–36]. For instance, Stephen [35] found that a teacher's perceptions of computers and of students' competence with computers directly influenced the type and amount of computer-supported activities in a classroom. Ertmer's [33] review of studies that examine how teachers' beliefs about pedagogy affect technology use highlighted the complexity of this relationship. Although beliefs are difficult to change, she suggested that strategies involving personal experiences, vicarious experiences, and socio-cultural influences may be successful. Finally, Teo [36] proposed a model of teacher technology use based on a combination of constructs from three previous models. Several constructs involved perceptions about technology: perceived usefulness, perceived ease of use, and perceived behavioural control. Teo found that if teachers perceived that technologies were useful and would increase their productivity, they were more likely to use them in their classroom. It is clear that teachers' beliefs drive their practice.

In addition to beliefs, we saw that teachers' background experiences played a role in their perception of technology. In our study, both teachers saw value in technology (e.g., increased productivity, efficiency, flexibility), but Mr. Aspen's all-out embracing of technology–even the playful aspects–contrasted strongly with Ms. Beech's more skeptical and practical view. This wide difference in viewpoint is in line with their very different background experiences. Ms. Beech's years of working "behind the scenes" with large computer systems gave her a very particular lens through which to view education's current emphasis on bringing new technologies into the classroom. She believed that "technology dictates behavior." She explained, "If you use technology, you're going to use the technology the way that a designer's built it." At one point, she referred to today's technologies as "toys." On the other hand, Mr. Aspen comes to technology with more of a consumer viewpoint, perhaps better able to appreciate the entertainment aspects of technology. Ertmer [33] describes how teachers' early experiences stay with them and affect their perception of later events, often acting like a filter through which new ideas must pass. Jones and Dexter [38] found that formal professional development activities organized at an administrative level often ignore the experiences and knowledge of teachers and stifle their creativity in using technology in teaching. Therefore, for adoption of technology to be successful, it must take into account teachers' previous experiences.

During the course of our study, several other interesting factors emerged. Even though the teachers were expected to utilize the technologies in the new classroom, the school administration gave them the freedom to decide *how* they would use the technologies and how quickly they would adopt each technology. The teachers were given some control and given the chance to assimilate the innovations into their own teaching practices according to their own teaching philosophy, learning preferences, and perceptions of technology. Furthermore, professional development occurred in progressive stages, with the teachers deciding on the format, when it would occur, and what technologies it would address. It has been suggested that this type of autonomy not only plays a critical role in motivation and creativity but is actually a basic human need [37]. Our participants certainly valued being in control of both their teaching and their learning.

In addition, Jones and Dexter [38] identified the role of informal collaboration among teachers as a factor in increasing technology use in the classroom. In this respect, our two teachers differed significantly. On the one hand, Ms. Beech preferred to work independently:

> Mr. Cedar [pseudonym] and Mr. Aspen, they do a lot of teaming up in there [STEM classroom]. That ain't for me. I interact with my students, so if there's another class in there, you know, it's like being in a one-room schoolhouse. It's just not my mode. I've been invited to team with them, and I have to say, I don't do one-room schoolhouses. My sister went to a one-room

> schoolhouse, and she always paid attention so she skipped [a grade]; but she always felt as if she missed something. It is also a sign of a past time that I won't indulge in necessarily, and so I would avoid that type of collaboration at all costs.

On the other hand, Mr. Aspen sought out opportunities to collaborate with colleagues in the STEM classroom. On several occasions, his class shared the space and resources simultaneously with another class:

> Mr. Cedar and I have been having our seventh hour class in the STEM classroom together. He's got six [students] and I've got twelve, and it works pretty well. Again, organized chaos. It really helps having the different learning spaces. He occupies two of them, and I occupy four of them and that's it. He'll answer some of my students' questions and I answer some of his students' questions. We teach each other's students all the time.

Mr. Aspen enjoyed the experience of co-teaching in the STEM classroom, and this is not surprising, since he had described his own personal learning environment as somewhat chaotic. Similarly, Ms. Beech's personal learning preference for a more controlled, quiet environment leads her to prefer teaching independently.

Finally,, with respect to the perception of technology, we noted a generational difference in the participants. Mr. Aspen showed much more confidence towards and willingness to embrace technology than Ms. Beech. Mr. Aspen was quick to try out new technologies in his classroom, while Ms. Beech seemed more skeptical. Although research conducted by Wang et al. [13] did not find this difference, this observation is supported by a recent Pew survey [12] that saw differences in teachers' responses to technology based on age group. According to the survey, teachers under the age of 35 were more likely than teachers age 55 and older to say they were "very confident" about using new digital technologies (64 % vs. 44 %). However, although this same survey reported that the oldest teachers (age 55 and older) were more than twice as likely as their colleagues under age 35 to say their students know more than they do about using the newest digital tools (59 % vs. 23 %), our participants both believed that their students were much more tech-savvy than they were.

5 Implications

The results of this study have implications for those seeking to maximize teachers' adoption of technologies into the learning environment. First, teachers' beliefs—formed and solidified over years of life experience—direct much of what happens in the classroom. These beliefs are deeply tied to teaching philosophy and perception of technology, making them a core factor in classroom technology adoption. In fact, Ertmer [33] suggested that in order to increase teachers' uses of technology to increase student learning, we must "consider how teachers' current classroom practices are rooted in, and mediated by existing pedagogical beliefs." Professional development activities that recognize and acknowledge the role such beliefs play by including strategies that help teachers expand their existing teaching philosophy to include technology use and that help teachers extend their perception of technology are more likely to be successful than activities that do not. For example, Ertmer [33] offered three strategies for teacher professional development that may help to change teacher beliefs. First, utilize personal experience. Give teachers opportunities to implement small changes and to be successful. Then, beliefs will begin to change. Second, provide vicarious experiences. Confidence in using technology will increase when watching others model this effectively. Third, encourage positive and supportive socio-cultural influences (e.g., learning communities and peer expectations of technology use). The influence of social networks and the school environment can be critical to how teachers view technology. Finally, it is important to realize that modifying beliefs and perceptions take time, and thus, so do change and the adoption of innovations.

In addition to beliefs, teacher autonomy may play an important role in the successful adoption of innovations. Both teachers in this study valued being in control of their own learning and having the opportunity to determine what they would learn, when they would learn it, and at what rate. It seems that their personal learning preferences along with a strong internal sense of "what is best" for teaching and learning influenced their classroom practices. Therefore, strategies that acknowledge and work with teachers' different learning preferences, combined with allowing teachers to decide their best learning path, may promote the best outcomes during any type of change process. Successful adoption of technology requires attention to teacher differences and plenty of options for teacher choice.

6 Limitations and Future Research

Generalizing the results of any case study should always be undertaken with care. Even so, our results are consistent with several other studies that have focused on teachers' adoption of technology and teachers' reaction to change [6, 17, 28, 30, 33, 40]. Furthermore, the case study design itself provides enough detail and rich description to allow other researchers to decide upon its transferability. Some of this detail comes from our participants. While our study focused on only two teachers, they were very different in almost every respect: demographics, personal and professional experience, and in most personal beliefs about technology and pedagogy. This maximum participant variability provided us with rich data and allowed us to capture a wide range of ideas and themes while reducing the chance of missing an important concept. In fact, this wide range of ideas renders this study very useful, as some of the details from this specific context will be found in most other educational environments. As Merriam [26, p. 225] states, "the general lies in the particular."

Since we studied a complex, active environment for over 3 years, it's not surprising that a variety of outside events impacted what we observed in these classrooms. Over the course of the study, many changes took place in the school and in the district. For example, a new director was hired early in the study and initiated the PLTW program as well as other initiatives. New after-school programs were implemented, many of them STEM-related. Mr. Aspen gained 2 years of valuable teaching experience, significant for a beginning teacher and most likely accounting for the evolution of his teaching practices over the course of the study. A longitudinal project is subject to these issues, but since the process of change can be lengthy, it was critical for us to spend enough time with our participants.

One area of future research should address the role autonomy plays in the adoption of technology and the modification of teaching practices. Some authors have discussed autonomy in relation to school change, teacher job satisfaction, and professionalism [41, 42]. Common [40, p. 205], for example, explained that teachers often have an image of themselves as having “characteristics of power, action, autonomy, and stability” while many school reformers hold a view of teachers that is quite different: “powerless, passive, uniform, and changeable.” The disconnect inherent in these two conflicting images may be a key element in the failure of many educational reform efforts. More specifically, Pearson and Moomaw [42] found that curriculum autonomy was inversely related to on-the-job stress, and general teaching autonomy was positively linked to empowerment and professionalism. Ernest [39] discussed the role of autonomy and reflection in changing teacher beliefs and enacting a new mathematics curriculum. However, none of these authors examined the role of teacher autonomy in the change process specifically when the change involved technology. It is clear that additional research focusing on the impact of teacher autonomy in the adoption of technology-based innovations and on the subsequent modification of teaching practices is still needed.

A second future research area involves our proposed model of factors that impact teachers’ technology use (Fig. 1) and its transferability to other educational environments. This model emerged from one particular setting, but educational environments vary greatly, both physically (e.g., classroom space and design, available resources such as books and computers, outdoor facilities, etc.) and socially (e.g., student culture and background, teacher colleagues, support and expectations of administrators and parents, etc.). Each different context has the potential to impact teacher practice in a unique way. In fact, Ernest [39] included social context in his model of teacher beliefs about teaching mathematics, stating that “the social context of the teaching situation, particularly the constraints and opportunities it provides” was a key element on which the practice of teaching mathematics depends. Therefore, it is important to study a model of teachers’ use of technology in a variety of school settings in order to determine if the factors and their interactions appear in the same way. Examining this model in different contexts will lead to a better understanding of how and why teachers use technology and allow administrators to better support and guide teachers throughout the adoption process.

References

1. Afshari, M., Bakar, K.A., Luan, W.S., Samah, B.A., Fooi, F.S.: Factors affecting teachers’ use of information and communication technology. Int. J. Instr. **2**, 77–104 (2009)
2. Angers, J., Machtmes, K.: An ethnographic-case study of beliefs, context factors, and practices of teachers integrating technology. Qual. Rep. **10**, 771–794 (2005)
3. Buabeng-Andoh, C.: Factors influencing teachers’ adoption and integration of information and communication technology into teaching: a review of the literature. Int. J. Educ. Dev. Inf. Commun. Technol. **8**, 136–155 (2012)
4. Mumtaz, S.: Factors affecting teachers’ use of information and communications technology: a review of the literature. J. Inf. Technol. Teach. Educ. **9**, 319–342 (2000)
5. Holden, H., Rada, R.: Understanding the influence of perceived usability and technology self-efficacy on teachers’ technology acceptance. J. Res. Technol. Educ. **43**, 343–367 (2011)

6. Organization for Economic Cooperation and Development (OECD): Creating Effective Teaching and Learning Environments: First Results from Teaching and Learning International Survey (2009)
7. Dexter, S.L., Anderson, R.E., Becker, H.J.: Teachers' view of computers as catalysts for changes in their teaching practice. J. Res. Comput. Educ. **31**, 221–239 (1999)
8. Nugent, G., Barker, B., Grandgenett, N., Adamchuck, V.: Impact of robotics and geospatial technology interventions on youth STEM learning and attitudes. J. Res. Technol. Educ. **42**, 391–408 (2010)
9. Hanson, K., Carlson, B.: Effective Access: Teachers Use of Digital Resources in STEM Teaching (2005). http://www2.edc.org/GDI/publications_SR/EffectiveAccessReport.pdf
10. Flores, A.: Examining disparities in mathematics education: achievement gap or opportunity gap? High Sch. J. **91**, 29–42 (2007)
11. Margolis, J., Estrella, R., Goode, J., Holme, J.J., Nao, K.: Stuck in the Shallow End: Education, Race and Computing. The MIT Press, Cambridge (2008)
12. Pew Research Center: How Teachers are Using Technology at Home and in Their Classroom. Pew Research Center, Washington, DC (2013)
13. Wang, S.K., Hsu, H.Y., Campbell, T., Coster, D.C., Longhurst, M.: An investigation of middle school science teachers and students use of technology inside and outside of classrooms: considering whether digital natives are more technology savvy than their teachers. Educ. Tech. Res. Dev. **62**, 637–662 (2014)
14. Bingimlas, K.A.: Barriers to the successful integration of ICT in teaching and learning environments: a review of the literature. Eurasia J. Math. Sci. Technol. Educ. **5**, 235–245 (2009)
15. Byrom, E., Bingham, M.: Factors Influencing the Effective Use of Technology for Teaching and Learning: Lessons Learned from the SEIR_TEC Intensive Site Schools. SouthEast Initiatives Regional Technology in Education Consortium (SEIR_TEC), Greensboro, NC (2001)
16. Zhao, Y., Frank, K.A.: Factors affecting technology uses in schools. an ecological perspective. Am. Educ. Res. J. **40**, 807–840 (2003)
17. Ertmer, P.A., Ottenbreit-Leftwich, A.T.: Teacher technology change: how knowledge, confidence, beliefs, and culture intersect. J. Res. Technol. Educ. **42**, 255–284 (2010)
18. Roehrig, G.H., Kruse, R.A., Kern, A.: Teacher and school characteristics and their influence on curriculum implementation. J. Res. Sci. Teach. **44**, 883–907 (2007)
19. Hall, G.E., Hord, S.M.: Implementing Change: Patterns, Principles and Potholes, 3rd edn. Pearson Education, Boston (2011)
20. Becker, H.J., Ravitz, J.: The influence of computers and internet use on teachers' pedagogical practices and perceptions. J. Res. Comput. Educ. **31**, 356–384 (1999)
21. Patton, M.Q.: Qualitative Evaluation and Research Methods, 3rd edn. Sage Publishers, Thousand Oaks (2002)
22. Yin, R.K.: Case Study Research: Design and Methods, 4th edn. Sage Publishers, Thousand Oaks (2009)
23. Stephen, M.L., Locke, S.M., Bracey, G.L.: Using a participatory design approach to create and sustain an innovative technology-rich STEM classroom: one school's story. In: Proceedings of the 6th International Conference on Computer Supported Education, pp. 30–38 (2014). doi:10.5220/0004849900300038
24. Corbin, J.M., Strauss, A.: Grounded theory research: procedures, canons, and evaluative criteria. Qual. Sociol. **13**, 3–21 (1990)
25. Strauss, A., Corbin, J.M.: Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory, 2nd edn. Sage Publications, Thousand Oaks (1998)

26. Merriam, S.B.: Qualitative Research: A Guide to Design and Implementation. Jossey-Bass, San Francisco (2009)
27. Miles, M.B., Huberman, A.M.: Qualitative Data Analysis, 2nd edn. Sage Publishers, Thousand Oaks (1994)
28. Hew, K.F., Brush, T.: Integrating technology into K-12 teaching and learning: current knowledge gaps and recommendations for future research. Educ. Tech. Res. Dev. **55**, 223–252 (2007)
29. Ertmer, P.A., Ottenbreit-Leftwich, A.T., Sadik, O., Sendurur, E., Sendurur, P.: Teacher beliefs and technology integration practices: a critical relationship. Comput. Educ. **59**, 423–425 (2012)
30. Richardson-Kemp, Yan, W.: Urban school teachers' self-efficacy, beliefs and practices, innovation practices and related factors in integrating technology. In: Society for Information Technology and Teacher Education International Conference Proceedings, vol. 1, pp. 1073–1076. AACE Press (2003)
31. Wozney, L., Venkatesh, V., Abrami, P.C.: Implementing computer technologies: teachers' perceptions and practices. J. Technol. Teach. Educ. **14**, 173–207 (2006)
32. Mishra, P., Koehler, P.A.: Technological, pedagogical, content knowledge: a new framework for teacher knowledge. Teach. Coll. Rec. **108**, 1017–1054 (2006)
33. Ertmer, P.A.: Teacher pedagogical beliefs: the final frontier in our quest for technology integration? Educ. Tech. Res. Dev. **53**, 25–39 (2005)
34. Baek, Y., Jung, J., Kim, B.: What makes teachers use technology in the classroom? Exploring the factors affecting facilitation of technology with a Korean sample. Comput. Educ. **50**, 224–234 (2008)
35. Stephen, M.L.: A Study of the Effects of Differences among Students' and Teachers' Perceptions of Computers and Experiences in a Computer-supported Classroom. Ph.D dissertation. Saint Louis University, St. Louis, MO (1997)
36. Teo, T.: Factors influencing teachers' intention to use technology: model development and test. Comput. Educ. **57**, 2432–2440 (2011)
37. Pink, D.: Drive: The Surprising Truth about What Motivates Us. Riverhead Books, New York (2009)
38. Jones, H.M., Dexter, S.: How teachers learn: the roles of formal, informal, and independent learning. Educ. Tech. Res. Dev. **62**, 367–384 (2014)
39. Ernest, P.: The impact of beliefs on the teaching of mathematics. In: Ernest, P. (ed.) Mathematics Teaching: the State of the Art, pp. 249–254. Falmer Press, London (1989)
40. Reid, P.: Categories for barriers to adoption of instructional technologies. Educ. Inf. Technol. **19**, 383–407 (2014)
41. Common, D.L.: Power: the missing concept in the dominant model of school change. Theor. Pract. **22**, 203–210 (1983)
42. Pearson, L.C., Moomaw, W.: The relationship between teacher autonomy and stress, work satisfaction, empowerment and professionalism. Educ. Res. Q. **29**, 38–54 (2005)

A Process Using Ontology to Automate the Operationalization of Pattern-Based Learning Scenarios

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Abstract. For most teachers-designers, operationalizing learning scenarios based on patterns just replicates traditional ways by adding course content and multimedia elements on learning management systems (LMS). We aim to go beyond this method by trying to engage the teachers-designers to design deployable learning scenarios. Using patterns for their design is proven to be an adequate solution to seek balance between the need of expressive instructional scenarios, and the technical constraints that occur while deploying these scenarios on learning management systems. Pattern's formal description is needed in order to translate the concepts of a pedagogical scenario, according to those embedded in the LMS. In this paper, we propose a process to structure, index, formalize, and finally adapt and operationalize the pattern-based learning scenarios. The presented process shows how the use of an ontology modeling learning scenario's concepts helps the automation of deploying the learning scenarios on an LMS. For that, this ontology has been extended with one representing a learning platform paradigm.

Keywords: Operationalization · Patterns · Ontologies · Instructional design · LMS · Teaching situation

1 Introduction

Over the last decade we have seen the rise of learning design tools oriented learning platforms as an alternative to the classic way of designing learning scenarios. Although this initiative is very useful for both teachers and learners because it allows taking advantage of the features proposed by learning platforms, we notice that the final result of these tools is facing problems with the "full-integration" and compatibility with institutional systems [1]. We note also, that despite of the significant advances in research work about learning environments, the operationalization phase of learning scenarios still remains a challenge. Teachers-designers still need assistance during this phase. We take interest in our research work to the "full cycle" of designing, operationalizing and adapting educational situations. We consider the operationalization as the development

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of specific research procedures that will result in empirical observations representing the learning scenario's concepts technology enhanced learning environments. One issue that we address is related to the machine-readable representations of teaching practice for technology enhanced learning environments. The other, addressed to the human-readable representations for sharing design knowledge between teachers. We need to find the right balance between the expressiveness and usability of a representation form [2]. Seeking answers for these issues, we studied the importance of the semantic technology and in particular the use of ontologies in developing learning design tools. Our focus was on how ontology-driven tools can support a learning design environment for teachers-designers to create designs under their own terms, and at the same time deployable under learning management systems terms, this, with a minimum of semantic loss. And since the facility of teacher's expressiveness is one of our major concerns, we studied how using a pattern-based learning design tool could help offering deployable learning scenarios. Their formalism has to respect a well defined structure in order to map easily the concepts embedded in the resulted learning scenario with the learning platform concepts. The semi-structured representation of scenarios will enable the capitalization and the reuse of teaching practices used by teachers. Most importantly, our hypothesis is that this representation allows browsing the patterns for relevant information retrieval and the deployment of this information. The final goal is to ensure an automatic deployment of the pattern-based learning scenarios on learning management systems such as Moodle [3] and Sakai [4]. We propose a five steps process, as presented in Sect. 4. The structuring and indexing phases provide a conceptual representation of theory and practice about learning scenarios, as well as about learning environments, and make it available for use, through a pattern-based tool for designing scenarios by teachers-designers as a Formalizing phase. This, ensures to benefit from the learning design vocabulary by being able to construct designs quickly, and co-construct knowledge. During the adaptation and operationalization phases, we suggest ways of combining conventional teaching and learning methods with the variety of features and tools embedded in learning management systems now available. We have studied as a first field of experimentation Moodle platform. We considered the Moodle 2.4 Meta modal proposed in [5] which gathers the entire pedagogical paradigm proposed in this environment.

The remaining of this paper proceeds as follows: Sect. 2 presents the related research works on instructional design for the operationalization of pedagogical scenarios. We focus on ontology based approaches for indexing and conserving the semantics of pedagogical objects and pattern based approaches to express and formalize scenarios; Sect. 3 overviews a case study we conducted to capture needs and constraints about operationalizing pattern-based learning scenarios; Sect. 4 describes our process based on patterns and ontologies to help achieving the automatic operationalization of learning scenarios.

2 Operationalization of Learning Situations

The field of instructional design and technology encompasses the analysis, the design, development, implementation, and evaluation of instructional processes and resources intended to improve learning [27]. Each step is highly affected by the previous ones.

We are interested in the operationalization of learning scenarios, which converges to the deployment of the designed learning scenarios, intended, or not, for a specific learning environment. In this section, and based on the correlation between designing scenarios and their deployment, we list several approaches expressing learning design knowledge and we emphasize their advantages and weakness in order to get a clearer picture the most suitable and adaptable one to automate operationalizing pattern-based learning scenarios.

Tools are emerging to support a variety of approaches to design learning. In particular, design oriented learning platforms, where teachers-designers create deployable learning scenarios. But this task appears to be complex for one who isn't very well familiarized with learning platforms technologies and computer environments. That's why many research works addressed these learning design issues, but few are those who take into account the aspect of operationalization. As entitled in this paper, we are working specifically on pattern-based designs, and we note that most of these learning design approaches and support tools do not explicitly integrate them in technological learning environment [6]. And when they do, as in Collage [7] case, the intervention of a platform expert is indispensable. This would be justified by the fastidiousness of this step. As a matter of fact, many difficulties and constraints are related to learning platforms, that range from the basic instructional language and rules to the implicit and complex structures related to each particular platform. Thus, these problems will create a semantic gap when considering learning scenarios concepts and platforms features. For example, designing tools based on modeling languages (EML) [8], more specifically the educational standard languages [9, 10] such as CADMOS [11] consider an XML notation, which is judged complex and tends to change the teachers-designers view of their scenarios. Also, since platforms do not follow any educational standards, deploying a standardized scenario would not be easy for a teacher to do. It will require the expertise of a pedagogical engineer. By another way, when those standardized designing tools take the operationalization step into account, it is always about one targeted learning environment (e.g.: CADMOS generates scripts to only deploy scenarios on Moodle).

As a solution to the lack of expressivity of Educational Modeling Languages, we chose a structured and formalized pattern approach for learning designs. Patterns provide a mean to abstract and represent good practices. They are used to capture expert knowledge of the teaching practice. A pattern is pictured as a three-part structure, specifying a problem and a solution addressing this problem according to a specific context [16]. Defined links between patterns (association, composition, etc.) are considered as a pattern language. [12] proposed a pattern structure and formalization in order to improve the instructional design process, taking advantage of what patterns offer in terms of structure and ease of expression but they do not address their integration into technology enhanced learning (TEL) systems.

Educational language representation was used to help to structure the proposed patterns [13]. We find many projects in the learning design with patterns area, as for example WebCollage [7], a designing tool based on pedagogical patterns. But within this approach, the implementation step still requires a platform expert assistance. [12] Suggests an engineering design process framework and an editing tool based on patterns, however, the operationalization aspect of the patterns is not addressed. Finally, GLUE!-PS is a tool dealing with deploying learning designs from multiple learning design language/authoring tool to multiple learning environments, yet, the design languages are based on IMS LD, which is too complex for the teachers [15].

We have noticed that most of the proposed design languages and tools do not preserve the semantic meaning of teachers' intention while transposing it on a learning system. There will be a lack of information, and as consequence a need for adapting the initial learning scenario. Moreover, we believe that the use of ontologies for both designing as well as operationalizing scenarios can solve this problem. Ontologies allow having one same semantic base which will retain the essence of the scenario during the transition between learning design and deployment phases. In educational fields, ontologies have played an important role as knowledge representation and sharing mechanism. We find ontologies based on IMS LD language [10], as well as ontologies describing the learning scenario [18] and also ontologies to describe common modules of learning platforms [20]. We noticed that the main advantages of these ontologies take place during the learning design phase. But we highly believe that it would simplify the implementation phase and help us to automate the deployment of patterns based scenarios.

We close this section by noting that the main concern of this work is to study the mechanisms supporting instructional design and scenario's deployment activity by teachers-designers. We are adopting a co-participative and iterative approach with teachers-researchers. The approach is called "Design Based Research" [19], a methodology suitable to both research and design of technology-enhanced learning environments (TELEs). Especially those design experiments involve both scientific and educational values, through scientific processes of discovery, exploration, confirmation, and transmission that create strong links among researching, designing, and engineering. By this approach, we try to reduce the gap between what a technology enhanced learning environment is and how it is defined theoretically (comparing what it is and how it is used in practice).

3 Deploying a Pattern-Based Learning Scenario: Moodle Case Study

As pattern-based design approaches have not been studied from the operationalization point of view, we seek through our study to capture the insights of deploying their resulted learning scenarios. We aim at defining a series of constraints to make explicit the structure to follow that would support the automatic operationalization of a pattern-based learning scenario. We also aim to prove the feasibility of automatically import a teacher's point of view of a learning scenario on a computer environment-with its embedded language- without losing information.

The research question tackled with this study is: which approaches models and/or techniques to consider for transforming the pattern-based scenarios into implementable models on different learning platforms?

If we look into the question, it is obvious that we need to explore both the human and the machine sides of a learning scenario. As in Fig. 1, we defined two starting points:

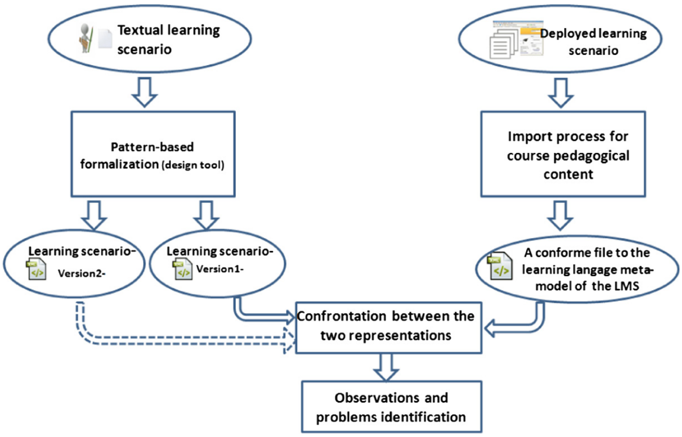

Fig. 1. Case study and methodology.

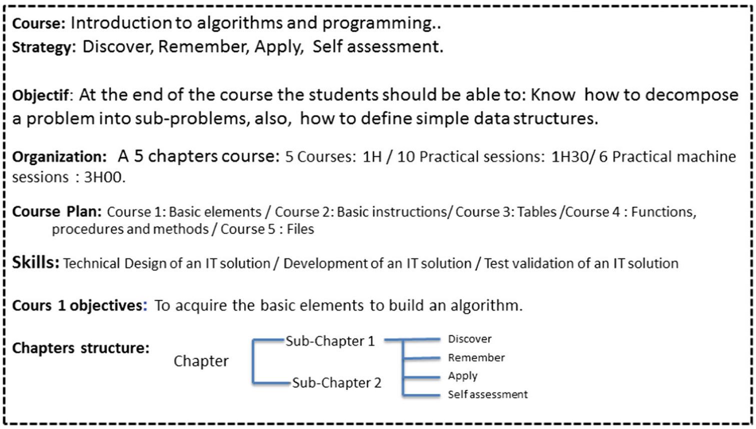

Fig. 2. Learning scenario extract.

In a first step we considered the textual version of a learning scenario (as intended by the teacher). The study was deployed on an algorithmic introductory course for students in computer science in first university degree (Fig. 2).

For the need of our study we extracted, during this first step, a list of learning concepts identified in the textual version of our scenario (ex. course plan, role, chapter, pedagogical objective, etc.). We intend to compare this list of concepts with the ones present on the deployed version of the scenario. For this comparison (explained farther in this section), we considered the scenario about the algorithmic course deployed manually on Moodle, which is our platform for experimentation). Then, we modeled this textual version of the teacher's intention using a pattern-based design tool to study the operationalization of the pattern-based design approaches [12]. The environment in which the activities were conceived allows teachers to visually build up learning scenarios (Figs. 3 and 4). As proposed by the tool, the design is not specifically intended to be implemented on a learning platform. The teacher might (or not) desire to create a platform oriented scenario, but the tool only allows him to design it based on generic patterns. This was our key to extract the problems that would face this kind of design when it comes to its deployment.

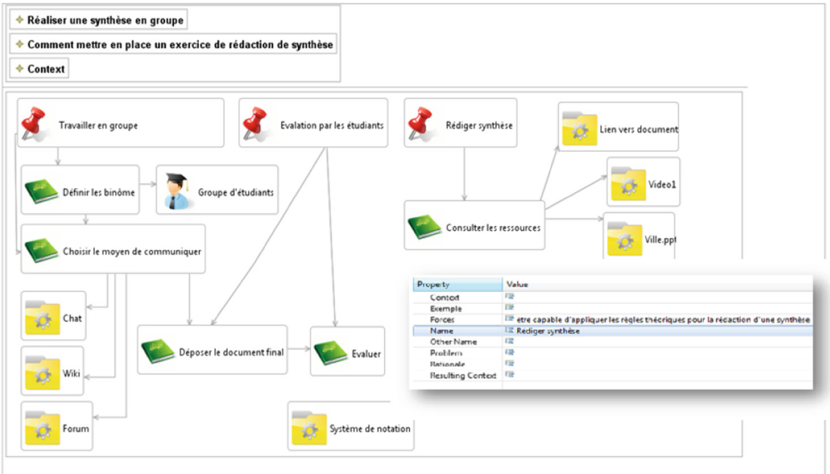

Fig. 3. Learning scenario Version 1.

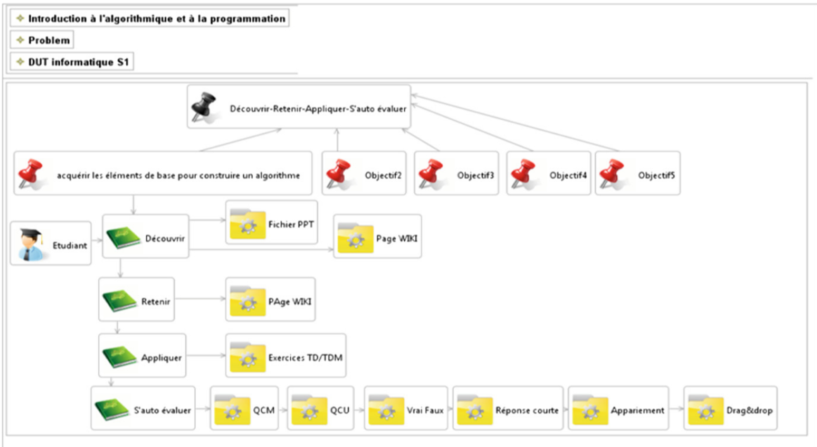

Fig. 4. Learning scenario Version 2.

We notice that for a textual version of the scenario, several pattern formalizations (without any loss of the learning concepts identified earlier) are possible to be designed. Since it is a pattern based tool, it guarantees the freedom of the teacher's expressiveness. We illustrated the two (but not the only) versions of our learning scenario (Figs. 3 and 4).

After the formalization step, come the observations from an operationalization point of view. We consider the study of Moodle XML files of our scenario (already operationalized manually). The idea behind this step is to identify the different needs and constraints around the deployment of learning scenarios on TEL environments. Following the same logic as in the earlier steps, we identified the learning scenario's concepts. Once again, the concepts list remained unchanged (ex. Course plan, role, chapter, pedagogical objective, etc.). This proves us the possibility to reproduce the same human point of view of a learning situation, designed using patterns, on a computer environment. Though, going the other way round (taking into account the deployed scenario and compare its concepts with the ones of the formalized scenario), we have noticed a lack of a set of information needed for the operationalization. We take for example the "Activities completion conditions" which was implemented on the platform but was absent in the formal version of the scenario, teachers didn't pay attention to add the information to their design, even though they are necessary to deploy their scenario.

Those first steps results lead us to conclude that the use of ontologies and meta-modeling when defining patterns for scenarios would reduce the semantic gap due to the transformation steps from the teacher's pedagogical intention to the platform.

The third and final step was to confront the XML file obtained from Moodle scenario (after transforming the backup file according to Moodle meta-model [5] (Fig. 5(2)) with the XML file generated from the pattern-based editing tool (Fig. 5(1)) (we kept two versions of the learning scenario formalization).

Through this confrontation, we noticed that: a pattern component corresponds, sometimes, to more than one educational concept. The identification is not "unique". We take as an example the Human resource concept "Student", it is defined in two different

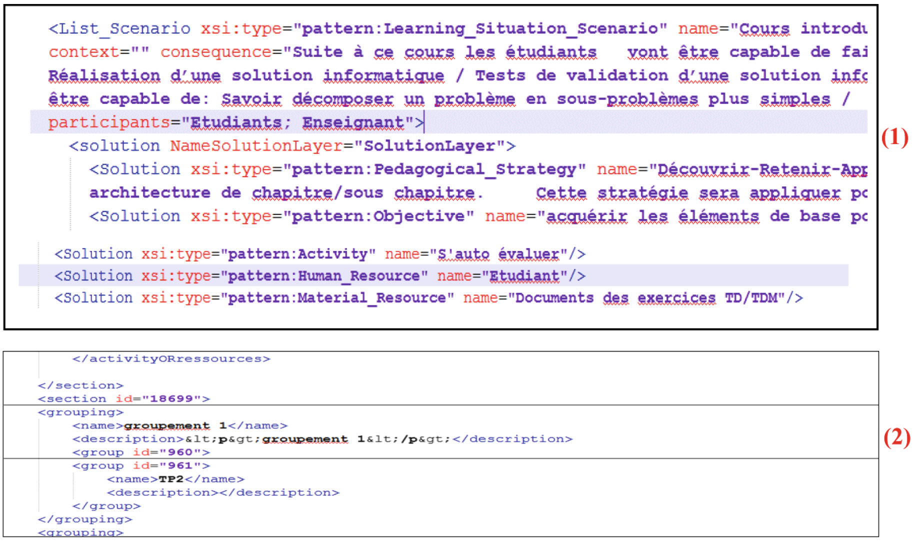

Fig. 5. XML scenario from the pattern based editor (1) and the platform (2).

places: as a Human resource Pattern (and as the "participant" pattern component of the design pattern "Learning situation" (Fig. 5). Also, the same pedagogical concepts are identified in different locations for each formalized version (according to the teacher's point of view, if we imagine a new version 3 of the scenario it may be represented in a complete different way). This makes it difficult to automatically implement the scenario on a computer environment. As a conclusion, we say that a pattern-based formalization, considering its semi structured data, may allow teachers-designers expressing their pedagogical needs without extensive loss of semantic information while representing their pedagogical intention with a pattern-based editing tool. On the other side, this open way of expressivity raises some difficulties for automating the learning scenario operationalization phase. In fact, learning platforms have their own pedagogical structure and language. So, the mapping of each element of the scenario with the relevant concepts in the platform is not obvious. We need to guide the teacher-designer toward a learning design approach that considers the operational needs and constraints, without forcing them to use any specific platform formalism.

Through this study, the previously cited features of a design based on patterns are worth considering for a platform oriented design. The goal is to successfully maintain the semantics of learning scenarios while transforming its pedagogical concepts into learning platforms features. But, we should first point our research on how could we provide to the teacher-designer the predefined components or "patterns", that would be used to gradually build a learning scenario ready to be directly implemented on any learning platform. We must define formalism for these patterns, so that the learning design process delivers a structure helping the automatic operationalization without limiting the degree of expressivity and reuse.

Designing learning scenarios based on patterns is not enough to achieve our automation goal, it is essential for us to combine patterns use with an indexing service. It would help to translate and implement each of the scenario's educational concepts in distinct learning platforms. In this direction, ontologies are also a very important part of this work, considering the knowledge representation and the sharing mechanisms they offer. We model and browse the learning vocabulary and language embedded in our experimental learning platform as well as in learning scenarios. Ontologies allow making a description of learning scenario's context, taking into account the level of granularity used in it (teaching program, course, learning unit, etc.).

4 Developing Pattern-Based Learning Designs: A Process Toward an Automatic Operationalization

In this section we describe a five step process as a mean to support learning designers to develop adequate learning designs ready to be directly implemented on a computer environment. We believe that we should offer to teachers a merging of expressivity, but it should be structured enough to make scenarios machine-readable representations of a teaching practice. It is a process where knowledge, competencies, learning activities, resources and delivery modes are pattern-based designed; they are then constructed explicitly in a framework based on our proposed learning scenario ontology. It helps to integrate the teacher's design into an e-learning environment that consists of a number of features and components interacting with learning design (e.g. tests, forums, chats, etc.). Our motto is that information about the computer environment should be added automatically in the learning design. This has the advantage that teachers-designers are not distracted from the problem of designing a learning scenario itself by all the constraints and technical requirements that the learning platforms involve. Let's begin with a general overview of the process: The first two steps structuring (1) and indexing (2) allow a mapping of the educational concepts (coming from the teaching practices and needs of designers) and the learning platforms concepts and features. Formalizing (3), this consists on developing pattern-based scenarios by teachers-designers. Then, we have the step to automate the implementation of scenarios (5). Before that, an adaptation step (4) is conducted to reduce the gap between the pedagogical language embedded in the platforms and the one used by teacher-designers. By the following we give more details about each step:

4.1 Structuring

The idea behind this step is to use generic description of a learning scenario as a universal basis to teacher's design. In other words, we have seen in Sect. 3, the need of an ontology modeling the concept of learning scenario. We can observe that the patterns-structured learning design scenarios, for a Moodle application, cause some difficulties while deploying on a computer environment. Some pedagogical concepts, such as "Activity completion condition" or "Activities order" could be missed or ignored. This lack of information prevents the automatic implementation of the scenarios. Based on this observation we propose to identify the different concepts of a learning scenario. The aim is to formalize these concepts in educational patterns (part 4.3). The identification is based on a research work about ontologies and educational standards (see in particular work presented by [17, 20, 21]). To build our namespace, we relied on the definition of a learning scenario and its dimensions to define our basic classes of concepts [22]. We consider different levels of granularity for a learning scenario: a structure unit, an instructional sequence and even an elementary activity (see Fig. 6). We used Dublin Core Standard [21], LOM[1] and MLR[2] to meet the universal description of the learning vocabulary. We also defined additional terms and concepts extracted from our study about learning scenarios [13, 17]. For that, we used OWL[3]/RDF[4] description as shown in Table 1. Once the vocabulary for the scenario is built, we proceeded for the classification phase. In order to offer pedagogically correct, significantly related and well structured patterns, we relied on Bloom's taxonomy to classify the educational knowledge and the different types of learning scenarios and activities [14].

1 http://edutechwiki.unige.ch/en/Learning_Object_Metadata_Standard.

2 https://elearningstandards.wordpress.com/tag/mlr/.

3 http://www.w3.org/2001/sw/wiki/OWL.

4 http://www.w3.org/RDF.

This classification will help the indexing work (presented next), because the structure of the learning scenario has to satisfy the requirements of its implementation. We are talking about how to ease the detection and extraction of the relevant pedagogical information in order to map it to the most suitable platform feature, having a minimal semantic gap. Semantic relations should be defined between the different levels (Hierarchy, Typology, Compositions, Use etc.). For that we use the "ObjectProperties in OWL description", also, some of the Dublin Core properties that meet our need. We note that as a result of our observations while confronting the two representations of a learning scenario from a platform independent design point of view, and a from a platform deployment one, we defined some constraints that we found obvious to us (Fig. 6). These constraints could be completed and ameliorated with the study of multiple versions of the same scenario on different learning environments.

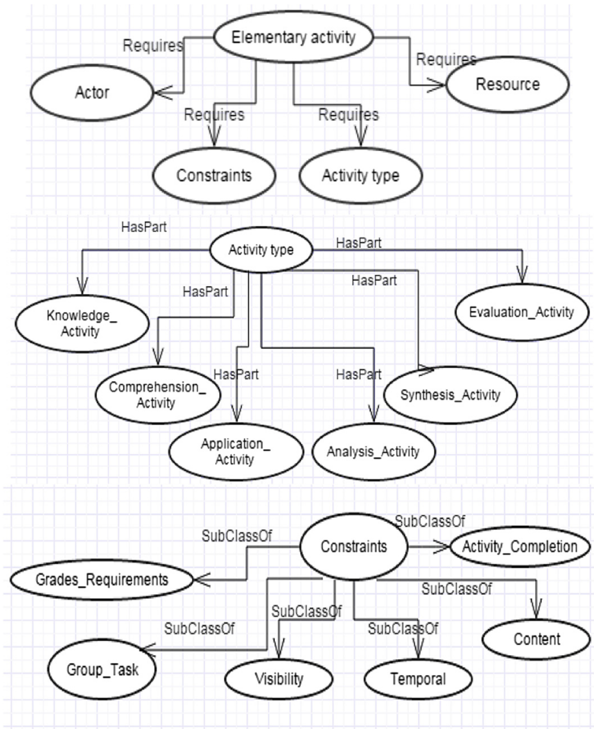

Fig. 6. A sample of our proposed ontology.

4.2 Indexing

Learning platforms offer features and components usually more suitable for use in a particular pedagogical situation. In this phase of the process, we help teachers to directly find the right equivalent of their design concepts. The idea is the alignment of our proposed ontology concepts with ones on each learning platform. It is a mapping

Table 1. A sample of domain vocabulary and its properties.

Concept	Type properties	Object properties	Concept
Learning Scenario	dct:description dct:identifier	owl:UnionOf	**elementary activity Activity sequence Structuration unit**
		owl: isVersionOf	**Learning Scenario**
		dct: Has	**Context**
		dct:HasPart	**Learning Scenario**
		dct: source	**Pattern**
		dct: creator	**Teacher Designer**
Structuration unit	dct:description dct:identifier	dct :hasPart	**Activity sequence**
Activity sequence	dct:description dct:identifier	owl: UnionOf	**elementary activity**
elementary activity:	dct:description dct:identifier dct:Value	dct: Requires	**Agent**
		dct: Requires	**Resources**
		dct: Requires	**Activity Type**
		dct: Requires	**Constraints**
Resources	dct:description dct:identifier dct:format	dct: Type	**Resource_Type**
DCMI: Agent	dct:description dct:identifier	dct:Mediator	**Teacher Student**
		dct:Type	**Group Individual**

between both learning platforms and learning scenarios pedagogical language. For that, we needed to create an ontology for the Moodle platform as a starting point, we intend to study more learning environment to enrich our indexation. The learning platform ontology is built based on its meta-model [5], it was identified through the process of identification and formalization the LMS instructional design language, and we also used the XSD-OWL transformation rules. Through our confrontation work (Sect. 3) between a pattern-based learning scenario and its operationalized version, we identified a component of the learning scenario that has been translated into several features on the learning platform (ex. “Student”). Consequently, we need this indexation as a necessary intermediate phase between the design and the operationalization of a learning scenario. We initially use our ontological description about the learning scenario concepts presented previously (4.1) (Fig. 6).

4.3 Formalizing

We aim at providing design ideas in a structured way, so that relations between design components are easy to create by teachers and easy to understand by computers. This formalization is the essence of a graphical meta-language for learning design that has an explicit translation to the learning platform pedagogical language using the previously described indexing service. This works in both directions: from visual notation to

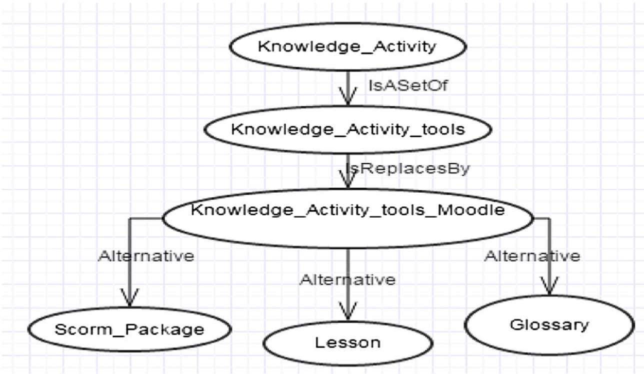

Fig. 7. Indexation example.

OWL-XML and from OWL-XML to visual notation. The formalism is mainly inspired by the design patterns that have been adopted in e-learning context [23] and the different formalisms used to describe the patterns [24]. The patterns are used to capture best practices and learning design knowledge that relates to ontologies presented in Sects. 4.1 and 4.2.

This step was proved essential taking into consideration the conclusions we made while modeling our scenarios with the pattern-based editing tool (Part 3). We noticed that it is more likely an open tool for learning design that allows a free expression leading to some difficulties for detecting a specific useful concept. For example, the course duration could be set differently from one version of a scenario to another. Another example as mentioned in part 3, the design of a Role (Student-teacher) isn't quite defined in a unique way, different pattern's components allowed the introduction of such information. Therefore, and in order to get over the automatic operationalization problems, the composition of a pattern, should not compromise the detection of the relevant information, it should be well formalized while offering for teachers some freedom to design their scenarios. To be able to locate any information in a pattern is the key to an automatic operationalization, also, ensured by the use of an ontology allowing combining the pedagogical language concepts of a teacher-designer and the learning platform concepts (cf. Sect. 4.5).

The following illustration Fig. 8 introduces a class diagram to define a learning design pattern classification that we propose. It is inspired from P-sigma's unified formalism [24]. Each Pattern is a set of three components: Header, Core and Resource. Header is the part helping to select patterns; it contains six items as detailed in Table 3. Core is the part where the teachers-designers give the solution in terms of modeling activities dealing with their pedagogical intentions. Finally, the Resource part is where the teachers-designers specify the learning object and tools to use. We note that it is a non-obligatory part in the design because sometimes, the need is only to design a flow of activities without any further specification, as in the case of designing a structuration unit, it is only a general definition of a set of objectives and their timeline.

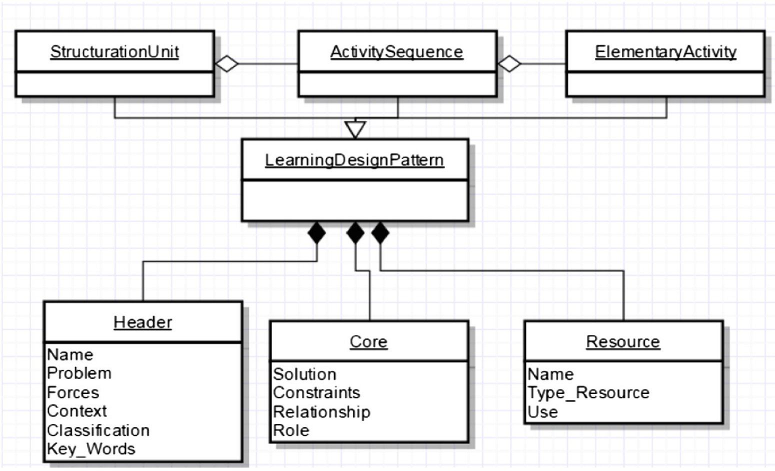

Fig. 8. Learning design pattern's formalism.

In addition to the p-sigma's structure, each of our patterns will be formalized as one of the learning scenario's levels of granularity mentioned in the literature; a learning scenario (LS) can be classified according to different criteria [22]: based on the granularity of the targeted learning situation. We identified three main categories of patterns when examining the main concepts of a scenario: "Structuation unit pattern", "Activity sequence" pattern and "Elementary activity" pattern, we define each type of a learning pattern (Table 2).

The table below describes the different items of a learning pattern; each one of the attributes is proposed after studying the need of balancing between our operationalization's constraints and theories around learning activities and pedagogical experiences (cf. Sect. 3). It is very important to note that by filling each of these items, the teacher-designer will create non ambiguous expressions of scenarios, abstract or concrete, that helps their reuse and more importantly, their deployment on a learning platform.

Table 2. Learning design patterns categories.

Pattern	Definition
Structuration unit	It corresponds to a learning situation in which a set of instructional sequences are gathered to constitute a logical unit about a given learning theme and dedicated to a specific audience
Sequence of activities	It corresponds to a learning situation where several activities or sequences are organized in order to reach a learning goal clearly defined in terms of knowledge and competencies. This organization must be able to express conditions of sequentiality, optionality and parallelism. It must also describe the associated data flow process
Elementary activity	It corresponds to a situation where one or several actors (learner, teacher, tutor, etc.) interact within a defined environment for a generally short and contiguous determined duration. An elementary activity may pursue a precise learning goal or more simply contribute to the goal associated with the sequence in which it will be integrated

Table 3. Learning design patterns components.

Item	Obligatory	Definition
Header		
Name	yes	The name of the pattern.
Problem (pedagogical objectif)	yes	The problem solved by the pattern.
Forces (pedagogical gain)	No	The pattern contributions through a collection of quality criteria.
Contexte	No	The pre-condition of pattern application.
Classification	Yes-No	This item allows distinguishing the pedagogical classification of each modeled activity.
Key words	yes	The mean to provide an intuitive definition of the pattern's context.
Core		
Solution	yes	The problem solution in terms of a pedagogical process of activities to follow. (As a graphical diagram)
Constraints	No	The rules necessary for the pattern's implementation.
Relationship	yes	The relation is expressed by an item (or another pattern) giving a type of link to the pattern described. The meaning of each link is based mainly on the pedagogical intention of the teacher (use, refine, follow etc.)
Role	No	The role defines the actor and the targeted of each part of the pattern's solution.
Resource		
Type of Ressourse	yes	The role of a mediated representation of the learning object.
Use	yes	The manner of how the resource is used. (Upload / download)

We chose each item of the proposed patterns' rubrics for their pedagogical contributions. It would be easy for a teacher-designer to define his scenario using his own ideas while translating them on the pattern's components intuitively. We take as an example the "Classification", each designer should be aware of the pedagogical classification of his intended activity: is it a knowledge activity? An evaluation? etc. So, it should not be hard for him to intuitively express his idea of a scenario using our proposed rubrics. As a second illustration, we consider the "context", it is dedicated to explain the pre-conditions, the prerequisites and the elements necessary for the use of the learning scenario based on the pattern, and as consequence we could directly detect the "completion conditions" or "grades constraints" for a deployed learning scenario.

4.4 Adaptation and Operationalizing the Pattern-Based Learning Scenario

This part of the process is described briefly. These two last steps of our process reflect the adjustments to apply on the learning scenario aiming to allow its automatic operationalization. The starting point is the pattern-based learning scenario Fig. 9; it should be formalized according to our proposed structure of a deployable pattern-based scenario. Depending on the target LMS, we use the module of learning scenario importation [25] to create an instantiation of the indexed concepts (as presented in Sect. 4.3), providing an XML file in accordance with the meta-model of the learning platform. The XSLT transformations are applied to cover the missing information and properties if necessary. This importation is automatic and does not require any intervention of the learning platform expert. The teacher only has to express his/her intention and pedagogical need in a semi-open structured language.

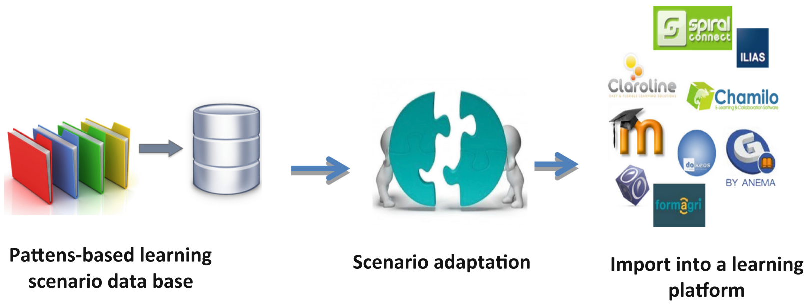

Fig. 9. Adaptation and operationalizing of a learning scenario.

4.5 Data Representation

Considering the data level point of view, the process of operationalization of learning scenarios involved is specified on different levels of representations (from a logical level to the physical level). As shown in the following illustration (Fig. 10), we define three levels of representation, depending on our operationalization needs of pattern-based scenarios.

Conceptual and Semantic Level. This first level of representation stands with the "Computationally Independent" viewpoint, and enables us to have an instructional design knowledge representation as closer as it could be to the language used by a human teacher as well as the language embedded in a learning management system. this layer is about the "Learning scenario" modeled in an ontology inspired. This ontology should reflect the different teaching strategies and the different levels of granularity in a learning scenario (a course, a learning unit etc.).

Keeping in mind our main objective to automate the operationalization process of learning scenarios, this ontology should include in its definition of concepts, the features provided by the various LMS to consider. This extension is an indexation of the instructional language of a learning platform. Building this semantic level ensures a common vocabulary for all teachers-designers and facilitates the interoperability between different LMS.

Learning/Instructional Design Level. The previously presented process's phases "structuring" and "formalizing" provide a representation of the pattern-based scenario.

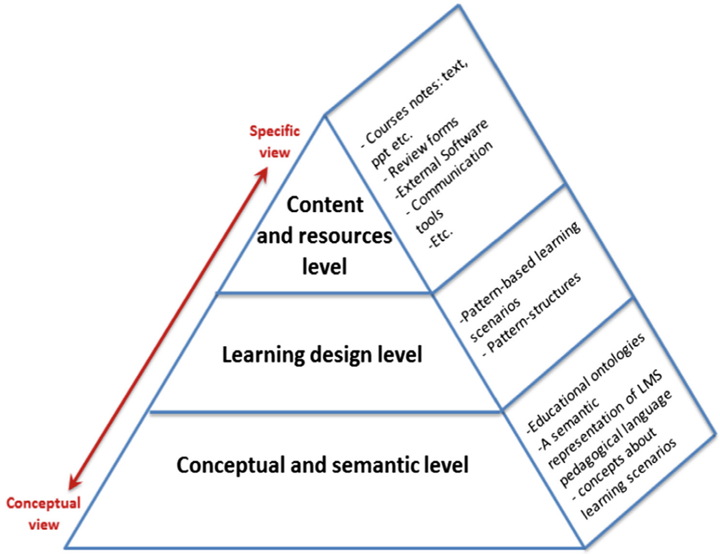

Fig. 10. Data layers for the automatic operationalization of pattern-based learning scenarios.

This result is what makes the content of the instructional design level. Each element of instructional design level is connected to one or more nodes from the semantic representation (level 1).

The elements are linked through "Instructional Relations" that establish the function and identify the various features to use on the learning platform while deploying the scenario.

Content and Resources Level. This content layer consists of different learning objects (documents and material resources) used in different contexts such as: course notes, exam's forms, the use of software and any mean of communication etc. A classification of these objects is considered [26] (presentation, practice, simulation, conceptual models, contextual information and representation objects). This level is strongly related to levels 2 and 3, it allows to instantiate the objects on learning platforms depending on the choice of use of the teacher-designer (as a support resource, mediation, building knowledge or as course application).

5 Conclusion

In this paper, we propose to offer a mean to guide the automatic operationalization of pattern-based learning scenarios. Especially, that it is based on a process that doesn't require from a teacher-designer to master the complicated instructional language of the learning platform. To validate whether this process allow us to meet our needs, a series of further work is planned. The structured ontology and the indexation of learning platforms concepts within this ontology (as proposed in Sects. 4.1 and 4.2) is considered as a data layer representation of our tool's architecture. A service of indexing and adaptation will be developed using Jena[5] library, which is a free and open source Java framework for building Semantic Web and Linked Data applications. Those services are the business back-end treatment of the teacher's Visual Design based on the proposed patterns. It will help the creation of a machine readable scenario, well adaptable to a target platform and ready to be operationalized without any extra effort from the teacher. We relied on a case study that helped us to highlight the problems facing the operationalization of learning scenarios based on patterns. We proved the need to use a semantic description of a learning scenario to minimize the gap between a human instructional language and a machine readable one. Moodle platform was our first application environment; we intend to extend our indexing phase by studying other learning platforms to demonstrate the feasibility of our proposition.

References

1. Mor, Y., Craft, B., Hernandez-Leo, D.: The art and science of learning design: editoral. Res. Learn. Technol. **21**, 1–8 (2013)
2. Agostinho, S., Bennett, S., Lockyer, L., Harper, B.: The future of learning design. Learn. Media Technol. **36**(2), 97–99 (2011)
3. Rice, W.: Moodle 2.0 E-Learning Course Development. Packt Publishing Ltd., Birmingham (2011)
4. Sakai. https://www.sakaiproject.org/ (2015)
5. Mawas, N.E., Oubahssi, L., Laforcade, P.: A meta-model based approach for identifying and formalizing LMS instructional design languages. In: Collaboration Technologies and Systems (CTS), pp. 159–166 (2015)
6. Chimalakonda, S., Nori, K.V.: A patterns-based approach for modeling instructional design and TEL systems. In: 14th International Conference on Advanced Learning Technologies, pp. 54–56 (2014)
7. Villasclaras-Fernández, E., Hernández-Leo, D., Asensio-Pérez, J.I., Dimitriadis, Y.: Web collage: an implementation of support for assessment design in CSCLmacro-scripts. Comput. Educ. **67**, 79–97 (2013)
8. Koper, R.: Modelling Units of Study from a Pedagogical Perspective: the Pedagogical Metamodel Behind EML. Technical Report OUNL (2001)
9. Martel, C., Vignollet, L., Ferraris, C., David, J.P., Lejeune, A.: Modeling collaborative learning activities on e-learning platforms, pp. 707–709 (2006)
10. IMS-LD. IMS Learning Design. http://www.imsglobal.org/index.html
11. Katsamani, M., Retalis, S., Boloudakis, M.: Designing a Moodle course with the CADMOS learning design tool. Educ. Media Int. **49**(4), 317–331 (2012)
12. Clayer, J.P., Piau-Toffolon, C., Choquet, C.: Assistance for learning design community-a context-awareness and pattern-based approach. In: CSEDU, pp. 293–300 (2014)
13. Buendía-García, F., Benlloch-Dualde, J.V.: Using patterns to design technology-enhanced learning scenarios. eLearning Papers **27**, pp. 1–12 (2011)

[5] https://jena.apache.org/.

14. Anderson, L.W., Krathwohl, D.R.: A Taxonomy for Learning, Teaching and Assessing: a Revision of Bloom's Taxonomy of Educational Objectives: Complete Edition. Longman, New York (2001)
15. Prieto, L.P., Asensio-Pérez, J.I., Dimitriadis, Y., Gómez-Sánchez, E., Muñoz-Cristóbal, J.A.: GLUE!-PS: a multi-language architecture and data model to deploy tel designs to multiple learning environments. In: Kloos, C.D., Gillet, D., Crespo García, R.M., Wild, F., Wolpers, M. (eds.) EC-TEL 2011. LNCS, vol. 6964, pp. 285–298. Springer, Heidelberg (2011)
16. Alexander, C., Ishikawa, S., Silverstein, M.: A Pattern Language, Town, Buildings, Constructions. Oxford University Press, Oxford (1977)
17. Abedmouleh, A., Oubahssi, L., Laforcade, P., Choquet, C.: An analysis process for identifying and formalizing LMS instructional language. In: ICSOFT, pp. 218–223 (2012)
18. Paquette, G.: A competency-based ontology for learning design repositories. Int. J. Adv. Comput. Sci. Appl. **5**(1), 55–62 (2014)
19. Wang, F., Hannafin, M.J.: Design-based research and technology-enhanced learning. ETR&D **53**(4), 5–23 (2005)
20. Montenegro, C., Cueva-Lovelle, J.-M., Sanjuán-Martínez, O., Gaona-Garcia, P.-A.: Modeling and comparison study of modules in open source LMS platforms with Cmapstool. Int. J. Interact. multimedia Artif Intell. 1–3 (2010)
21. LOM Specification, Learning Object Metadata. http://ltsc.ieee.org/wg12/index.html
22. Weibel, S.: Dublin core metadata for resource discovery. Internet Engineering Task Force RFC 2413.222 (1998)
23. Pernin, J.P., Lejeune, A.: Dispositifs d'apprentissage instrumentés par les technologies: vers une ingénierie centrée sur les scénarios. Technologies de l'Information et de la Connaissance dans l'Enseignement Supérieur et de l'Industrie. Université de Technologie de Compiègne, pp. 407–414 (2004)
24. Goodyear, P., Yang, D.: Patterns and pattern languages in educational design. In: Handbook of Research on Learning Design and Learning Objects: Issues, Applications and Technologies, pp. 167–187 (2008)
25. Gui, J., Fredj, M., Conte, A., Hassine, I., Giraudin, J.-P.: A tool and a formalism to design and apply patterns. In: Bellahsène, Z., Patel, D., Rolland, C. (eds.) OOIS 2002. LNCS, vol. 2425, pp. 135–146. Springer, Heidelberg (2002)
26. Churchill, D.: Towards a useful classification of learning objects. Educ. Tech. Res. Dev. **55** (5), 479–497 (2007)
27. Andrews, D.H., Goodson, L.A.: A comparative analysis of models of instructional design. J. Instr. Dev. **3**(4), 2–16 (1980)

The Impact of Rubric-Based Peer Assessment on Feedback Quality in Blended MOOCs

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Abstract. Massive Open Online Courses (MOOCs) have gained popularity in the past few years as a new form of open learning. Unlike assessment in classroom settings, the methodology to assess learning in open environments such as MOOCs represents a big challenge from the pedagogical perspective. Thus, there is a need to think about scalable assessment methods for accrediting and recognizing learning in MOOCs in an efficient and effective way. Peer Assessment is increasingly discussed in the recent MOOC literature as a potential solution to address this challenge. The problem remains, however, how to ensure the quality of the peer assessment feedback. In this paper, we investigate the potential of rubric-based peer assessment to make the assessment process in blended MOOCs (bMOOCs) more effective in terms of transparency, validity, and reliability. Moreover, we explore which peer assessment model fits best in a bMOOC context.

Keywords: Massive open online courses · Moocs · Blended MOOCs · bMOOCs · Peer assessment · Collaborative learning · Rubrics · Peer feedback

1 Introduction

Massive Open Online Courses (MOOCs) represent a new Technology Enhanced Learning (TEL) model that has succeeded in incorporating video-based lectures and new ways of assessment in courses that are offered on the Web for a huge number of participants around the globe without any entry requirements or tuition fees, regardless of their location, age, income, ideology, and education background [43]. Different types of MOOCs have been introduced in the MOOC literature. Daniel [8] classified MOOCs into connectivist MOOCs (cMOOCs) and extension MOOCs (xMOOCs). The vision behind cMOOC is based on the theory of connectivism, which fosters connections, collaborations, and knowledge sharing among course participants. The second type,

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xMOOCs is following virtue of behaviorism and cognitivist theories with some social constructivism aspects. xMOOC platforms were developed by different elite universities and usually distributed through a third party provider such as Coursera, edX, and Udacity.

Much has been written on MOOCs about their design, effectiveness, case studies, and the ability to provide opportunities for exploring new pedagogical strategies and some business models. In fact, most of existing MOOCs are especially interesting as a source of high quality content including video lectures, testing, forms of discussion and other aspects of knowledge sharing. Despite their popularity and the large scale participation, a variety of concerns and criticisms in the use of MOOCs have been raised. Yousef et al. [43] in their comprehensive analysis of the MOOC literature reported that the major limitation in MOOCs is the lack of human interaction (i.e. face-to-face communication). Furthermore, one important obstacle that prevents MOOCs from reaching their full potential is that they are rooted in behavioral learning theories. In other words MOOCs so far still follow the centralized learning model using the traditional teacher-centered education that controls the MOOCs and its activities. Efforts in student-centered MOOCs, based on connectivism and constructivist principles that emphasize the role of collaborative and social learning are exceptions but not the rule [43]. Other researchers point out concerns about the limitations of MOOCs. These concerns include pedagogical problems concerning providing the participants with timely, accurate, and meaningful feedback of their assignments tasks [16, 21]; lack of interactivity between learners and the video content [15]; high drop-out rates, on average 95 %, of course participants [6, 8]. Plausible reason for the latter problem might be the complexity and diversity of the participants. This diversity is not only related to cultural and demographic attributes, but also takes into account individual motives and perspectives when enrolled in MOOCs [41].

In order to address these limitations, a new design paradigm emerges, called blended MOOCs (bMOOCs) is increasingly discussed in the MOOC community. Blended learning has been widely identified as a combination of face-to-face and online learning activities. As an instance of blended learning, bMOOCs aim at bringing in-class (i.e. face-to-face) interactions and online learning components together as a blended environment, taking into account the important openness factor in MOOCs [2, 12, 26]. The bMOOC model has the potential to bring human interactions into the MOOC environment, foster student-centered learning, support the interactive design of the video lectures, provide effective assessment and feedback, as well as contemplate the diverse perspectives of the MOOC participants.

However, the ability to evaluate a large scale of participants in MOOCs is obviously a big challenge [37]. The current versions of MOOCs are used traditional assessment methods. These include e-tests, quizzes, multiple-choice and short answer questions [10, 18]. These methods are limited in evaluating learners in open and distributed environment effectively. Moreover, these methods are relatively easy to apply in science curricula courses. However, it is difficult to apply them in humanities curricula courses, mainly due the nature of these courses, which are based on the creativity and imagination of the learners [31]. This provides strong ground for alternative assessment methods that provide effective and constructive feedback to MOOCs participants about their open-ended exercises, or essays.

The generic aim of most assessment methods is to provide such kind of feedback usually involve teaching staff correcting and grading the assignments. In the MOOCs scenarios, this requires substantial resources in terms of time, money, and manpower. To alleviate this problem, we argue that the most suitable way is to look for assessment methods that employ the wisdom of the crowd. Such assessment methods include portfolios, wrappers, self-assessment, group feedback, and peer assessment [5, 9].

Learner's portfolio is an approach to authentic assessment that potentially enables large classes to reflect on their work [23]; wrapping assessment techniques use a set of reflective questions to engage participants in self-assessment and self-directed learning [38]; self-assessment can be used to prompt learners' reflection on their own learning outcomes; and peer assessment refers crowdsourcing grading activities where learners can take responsibility for rating, evaluating, and providing feedback on each other's work [34].

We considered these different crowdsourcing assessment activities, and concluded that the most suitable assessment method in our scenario is to involve the learners themselves under supervision and guidance from the teachers. We think that peer assessment activities that involve learners themselves in the assessment process can play a crucial role in supporting an effective MOOC experience. So far, little research has been carried out to investigate the effectiveness of using peer assessment in a bMOOC context [5, 33]. In an attempt to handle this assessment issue, this paper presents in details a study conducted to investigate the effectiveness of using peer assessmenton learners' performance and satisfaction in the bMOOC environment L^2P-bMOOC.

2 L^2P-BMOOC: First Design

Current MOOCs suffer from several critical limitations, among which are the focuses on the traditional teacher-centered model, the lack of human interaction, as well as, the lack of interaction between learners and the video content [15, 19, 44].

L^2P-bMOOC is a bMOOC platform on top of the L^2P learning management system of RWTH Aachen University, Germany. It was designed and implemented to address these limitations. L^2P-bMOOC supports learner-centered bMOOCs by providing a bMOOC environment where learners can take an active role in the management of their learning activities, thus harnessing the potential of bMOOCs to support self-organized learning [4]. L^2P-bMOOC fosters human interaction through face to face communication and scaffolding, driven by blended learning approach. The platform includes a video annotation tool that enables learners' collaboration and interaction around a video lecture to engage the learners and increase interaction between them and the video content. This means that L^2P-bMOOC embodies evolved concept which differs from traditional MOOC environments, where learners are limited to viewing video content towards collaborative and dynamic one. Learners are encouraged to organize their learning, collaborate with each other, create and share their knowledge with others.

In L^2P-bMOOC, video lectures are structured, collaboratively annotated in mind-map representation. Figure 1 shows the workspace of L^2P-bMOOC which consists of a course selection section, an unbound canvas representing the video map structure of the lecture, and a sidebar for new video node addition and editing of video properties. Possible actions on a video node include video annotations, video clipping, social bookmarking (i.e. attaching external web feeds), and collaborative discussion threads [40].

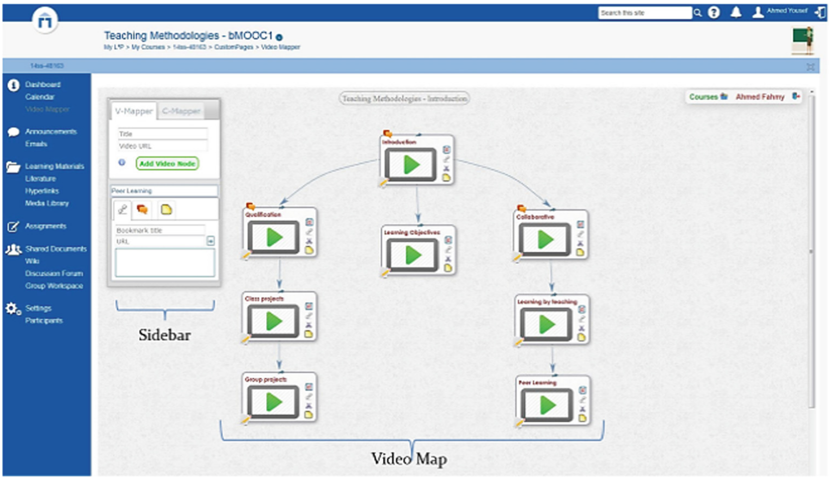

Fig. 1. L^2P-bMOOC workspace.

The annotation section of video nodes is displayed in a separate layer above the main page and can be opened by clicking the "Annotation icon @" attached to map nodes. It consists of three main blocks: Interactive timeline, list of existing annotations and creation form for new annotations (see Fig. 2). The interactive timeline visualizing all annotations is located right under the video and is synchronized with the list of complete annotations. By selecting timeline items users can watch the video directly starting from the part to which the annotation points to. The timeline range corresponds to video duration and can be freely moved and zoomed into. Timeline items also include small icons that help to distinguish three annotation types: Suggestion, Question and Marked Important.

As pilot test for this platform was the bMOOC "Teaching Methodologies" course delivered by the Fayoum University, Egypt in cooperation with RWTH Aachen University. It started in March 2014 and ran for eight weeks. This course was offered both formally to students from Fayoum University and informally with open enrollment to anybody who was interested in teaching and learning methodologies. At the end of the course, there were 128 active participants. 93 were formal participants who took the course to earn credits from Fayoum University. These participants were required to complete it and obtain positive grading of assignments. The rest were informal participants undertaking the learning activities at their own pace without receiving any credits. The teaching staff provided six video lectures and the course participants have added 27 related videos. The course was taught in English and the

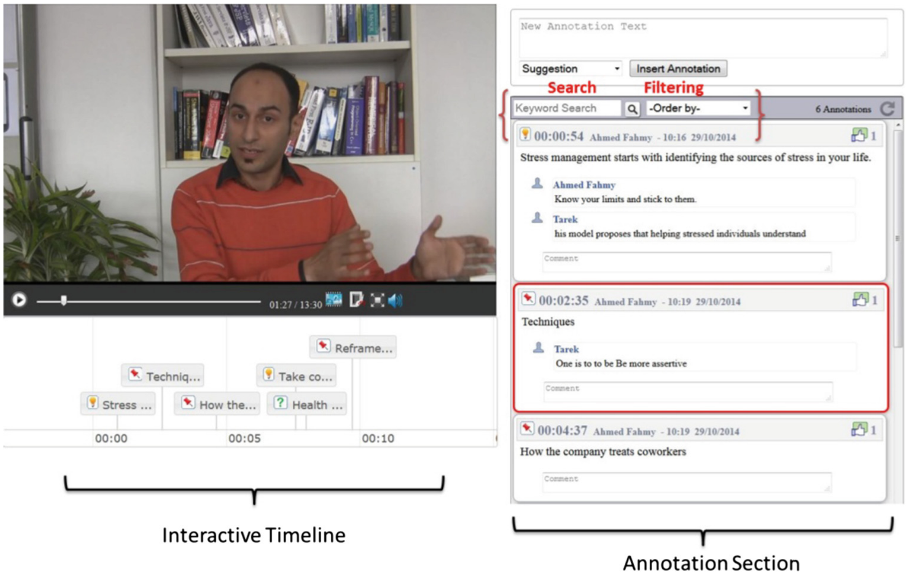

Fig. 2. Video annotation panel in L^{2}P-bMOOC.

participants were encouraged to self-organize their learning environments, to present their own ideas, collaboratively create video maps of the lectures, and share their newly-acquired knowledge through social bookmarking, annotations, forums, and discussion threads [42].

To evaluate whether the platform supports and achieves the goals of "network learning" and "self-organized learning", we designed a qualitative study based on a questionnaire. This questionnaire utilized a 5-point Likert scale with range from (1) strongly disagree, to (5) strongly agree. We derived the results and reported conclusions based on the 50 participants who completed and submitted the questionnaire by the end of the survey period. The results obtained from this preliminary analysis are summarized in the following points:

The collaboration and communication tools (i.e. group workspaces, discussion forums, live chat, social bookmarking, and collaborative annotations) allowed the course participants to discuss, share, exchange, and collaborate on knowledge construction, as well as, receive feedback and support from peers.

The results further show that the majority agreed that L^{2}P-bMOOC allowed them to be self-organized in their learning process. In particular, the participants reported that it helped them to learn independently from teachers and encouraged them to work at their own pace to achieve their learning goals.

The study, however, identified two problems concerning assessment and feedback. The participants had some difficulties in tracking and monitoring their learning activities and those of their peers. The second issue that pointed out was the limited ability to evaluate and give effective feedback for their open-ended exercises [42].

A possible solution for the first problem was the introduction of learning analytics features. These features can improve the participants' learning experience through e.g. the monitoring of their progress and supporting (self)-reflection on their learning activities. To alleviate the second problem, we opted for peer assessment. As motivated in the previous section, one possible scenario for peer assessment is the evaluation of assignment that cannot be corrected automatically, such as open-ended exercises and essays.

In August 2014, we conducted a second case study to evaluate the usability and effectiveness of the learning analytics module. The focus of this study was to examine to which extent this module supported personalization, awareness, self-reflection, monitoring, and recommendation in bMOOCs [39]. What still remains unclear is how to leverage peer assessment in bMOOCs. The paper at hand investigates the application of peer assessment in bMOOCs. It aims to address the following research questions:

- What is the learners' perception of satisfaction with the *usability* of the peer assessment module in L^2P-bMOOC?
- Does the peer assessment module *improve learning outcomes*?
- Does the peer assessment module provide a *reliable and valid feedback* for participants?
- Which *peer assessment model* fits best in a bMOOC context?
- What are the future research opportunities in the area of peer assessment that should be considered in the development of bMOOCs environments?

3 Peer Assessment in MOOCs

Assessment and feedback are essential parts of the learning process in MOOCs. Collecting valid and reliable data to grade learners' assignments; identifying learning difficulties and taking action accordingly; and using these results, are just a portion of the measures to improve the academic experience [20]. Many MOOCs use automated assessments (e.g. multiple-choice questions, quizzes) which strongly focus on the cognitive aspects of learning. The key challenge of automated grading in MOOCs is inability to capture the semantic meaning of learners' answers; in particular on open-ended questions [20].

On the other hand, peer assessment is a promising alternative evaluation strategy in MOOCs, as a critical evaluation method for scaling the grading of open-ended assignments [28]. Peer assessment represents a shift from a teacher-directed perspective to one where learners can be actively involved in the assessment loop [27]. This method of assessment is suitable for activities, like exercises, assignments, or exams which do not have clear right or wrong answers in humanities, social sciences, and business Studies [27]. Several studies have been conducted to investigate the impact of using peer assessment in traditional classroom instruction, and acknowledged a number of distinct advantages. These include: increase in learners' responsibility and autonomy, new learning opportunities for both sides (i.e. givers and receivers of work review), enhanced collaborative learning experience, and strive for a deeper understanding of the learning content [34, 35].

Unfortunately, so far, there has been little discussion about using peer assessment in MOOCs on humanities, social sciences, or business Studies. In the next section, we will discuss specifically how MOOCs providers are using peer assessment in their courses.

3.1 Coursera

Coursera has integrated a peer assessment system in its learning platform to evaluate and provide feedback for at least 3 to 4 assignments. Coursera provides learners with an optional evaluation matrix to improve peer assessment results. In addition, learners have the opportunity to self-evaluate themselves [21, 28]. The peer assessment system in Coursera involves three main phases: (1) submission phase, (2) evaluation phase, and (3) publishing results as shown in Fig. 2 [7]. Until recently, there has been no reliable evidence on how peer assessment affects the learning experience in Coursera (Fig. 3).

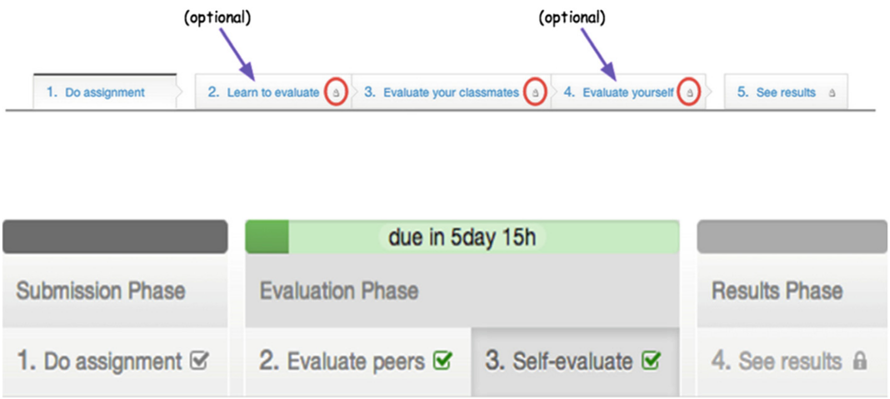

Fig. 3. Peer assessment in Coursera [7].

In several MOOCs offered by the Pennsylvania State University and hosted online by Coursera, learners reported that, they mistrusted the peer assessment results. Moreover, they outlined some of the issues of peer assessment, such as the lack of peers' feedback, accuracy, and credibility [33].

3.2 edX

In Peer assessment in edX, exists in a very similar fashion like in Coursera. In the case of edX peer assessments, learners are required to review a few assignments samples that have already been graded by the professor before evaluating their peers. After learners proved that they can assign grades similar to those given by the professor, they are permitted to evaluate each other's work and provide feedback, using the same rubric [11] (Fig. 4).

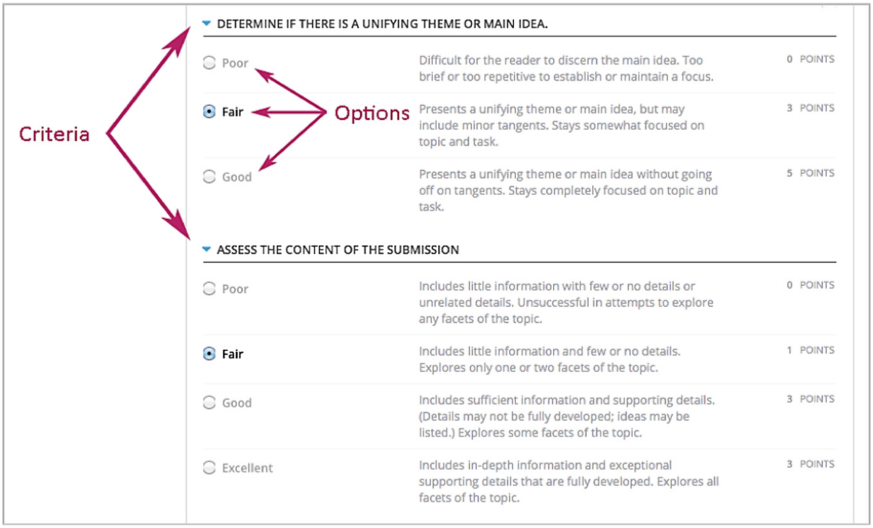

Fig. 4. Peer assessment rubrics in edX [11].

3.3 Peer Assessment Issues in MOOCs

The Peer assessment is valuable evaluation method used to facilitate learners for receiving deeper feedback on their assignments but it is not always as effective as expected in MOOCs scenarios [33]. Jordan [17] shows that MOOCs which used peer assessments tend to have lower course completion rates compared to the ones that used automated assessment. In general, there are several possible factors that can explain the lack of effectiveness of peer assessment in MOOCs:

- The issue of scale [33].
- The diversity of reviewers' background and prior experience [41].
- The lack of accuracy and credibility of peer feedback [33].
- The lack of transparency of the review process.
- MOOCs participants do not trust the validity and reliability of peer assessment results due to the absence of a clear evaluation authority (e.g. teacher).
- The low perceived expertise; i.e. peer feedback is not always as effective as teacher feedback [22].
- Peer assessment in MOOCs employs fixed grading rubrics. Obviously, different exercise types require different assessment rubrics [30]

4 Peer Assessment in L²P-BMOOC

In this paper, we focus on the application of peer assessment from a learner perspective to support self-organized and network learning in bMOOCs through peer assessment rubrics. In the following sections, we discuss the design, implementation, and evaluation of the new peer assessment module in L²P-bMOOC.

4.1 Requirements

In order to enhance L^{2}P-bMOOC with a peer assessment module, we collected a set of requirements from recent peer assessment and MOOCs literature [14, 33, 43]. Then, we designed a survey to collect feedback from different MOOC stakeholders concerning the importance of the collected requirements. The demographic profile of this survey was distinguished into professors and learners as follows:

- Professors: 98 professors who had taught a MOOC completed this survey. 41 % from Europe, 42 % from the US and 17 % from Asia.
- Learners: 107 learners participated in the survey. A slight majority of these learners were males (56 %). The learners' ages ranged from 18 to 40+, with almost 65 % between the ages of 18 and 39. 12 % High school and other levels of studying, 36 % were studying Bachelor, 40 % Master's, 12 % PhD. All of them had taken one or more online courses, and 92 % had participated in MOOCs. These learners came from 41 different countries and cultural backgrounds in Europe, US, Australia, Asia, and Africa. A summary of the survey analysis results are presented in Table 1.

Table 1. L^{2}P-bMOOC peer assessment requirements (N = 205).

No	L^{2}P-BMOOC peer assessment requirements		
	Items	M	SD
1	Students should receive feedback and/or correct answers to each assignment task	4,57	0.90
2	Provide formative assessment and feedback within the learning process	4.12	1.05
3	Design flexible guidelines and rubrics for each task	4.53	0.84
4	Give clear directions and time limits for in-class peer review sessions (i.e., face-to-face interaction) and set defined deadlines for out-of-class peer review assignments	4.36	1.06
5	Each student doing the peer review should explain his or her evaluation	4.32	0.79
1. Strongly disagree … **5.** Strongly agree			

The agreeability means of peer assessment requirements is quite high at above 4. In particular, indicators 3 and 5 call for specific, albeit flexible guidelines and rubrics. This is important to avoid grading without reading the work, or not following a clear grading scheme, which negatively impacts the quality of the given feedback [44].

Based on the peer assessment literature review and the survey results, we derived a set of requirements to support peer assessment in L^{2}P-bMOOC, as summarized below:

- **User Interface:** The interface should be simple, understandable, and easy to use while requiring minimal user input. The interface design of the module should take usability principles into account, and go through a participatory design process [24].
- **Rubrics:** Provide learners with flexible task-specific rubrics that include descriptions of each assessment item to achieve fair and consistent feedback for all course participants.

- **Management:** Peer assessment should be easy to manage. The module ought to be integrated into the platform with features for activation and deactivation.
- **Scalability:** The fundamental difference between MOOCs and traditional classroom is the scale of learners. Consequently, scalability should be considered in the implementations of peer assessment module in L^{2}P-bMOOC.
- **Collaborative Review:** Provide mechanisms for a collaborative review process which involves the input of more than one individual participant.
- **Double Blind Process:** Peer assessment module should support the double blind review process. Neither the assignment authors know the reviewers identities, nor the reviewers know the assignment authors identities.
- **Deadlines:** Peer assessment module should provide two deadlines for each task: the submission deadline for learners to submit their work, and the other for the peer grading phase.

5 Implementation

The peer assessment module in L^{2}P-bMOOC consists of the six components as shown in Fig. 5. These peer assessment components are classified according to the following methods:

- Teachers need methods to define assignment tasks and manage the review process.
- Learners need methods to see assignment tasks and submit solutions, as well as, to provide and receive peer reviews.

Form the technical perspectives we used Microsoft SharePoint 2013 as underlying platform. SharePoint offers a solid base for MOOCs development, while offering a

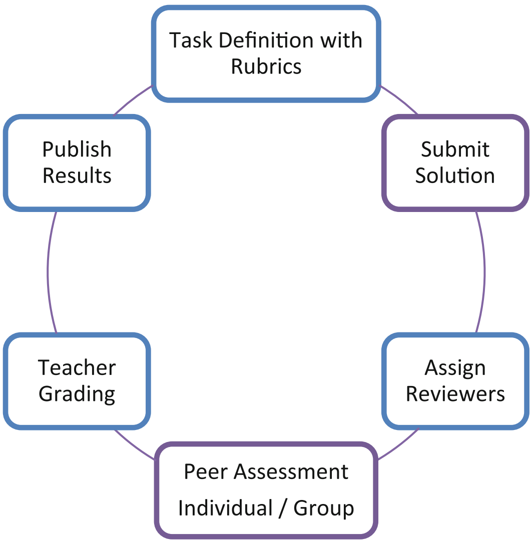

Fig. 5. Peer assessment workflow.

wide range of other advantages. These include scalability, security, customization and collaboration. The internal list structure of SharePoint makes it easy to implement fine grained rights on individual list items, which allow for easier rights management in L²P-bMOOCs peer assessment module. Basically, it is easy to configure who can see what on a given point in time.

5.1 Teacher Perspective

The peer assessment module in L²P-bMOOC consists of a centralized place of actions (navigation ribbon) to help teachers to define, manage, and navigate the assignment tasks, as shown in Fig. 6.

Fig. 6. Teacher navigation ribbon.

The ribbon actions provide complete set of tools to define peer assessment tasks, manage task-specific rubrics, assign reviewers, give final grades, and publish the results.

5.1.1 Task Definition with Rubrics

The task definition begins with defining some basic attributes of the assignments. These attributes include the name and description, the deadlines, and the associated materials and resources. Additionally, there are a number of specific settings to be configured, which are related to the peer assessment itself. These specific settings are concerning the start and end of the review, the review impact on the final grade, and the task-specific rubrics (see Fig. 7).

There are well documented results that provide methods to enhance the effectiveness of peer assessment by asking direct questions for the peer to answer, in order to assess the quality of work by the author [13]. This way, the reviewer can easily reflect on the quality of work in a goal-oriented manner. Hence, we implemented a rubric system that allows tutors to define specific questions related to each task, and also reuse pre-defined rubrics. The process for defining rubrics is included in the task definition itself. Typical rubric has two attributes: name and the actual rubric question. Further, it contains descriptions that define the learning outcome and performance levels to provide enough information to guide learners in doing the peer assessment review. Teachers can select multiple rubrics to associate with an assignment definition, as shown in Fig. 8.

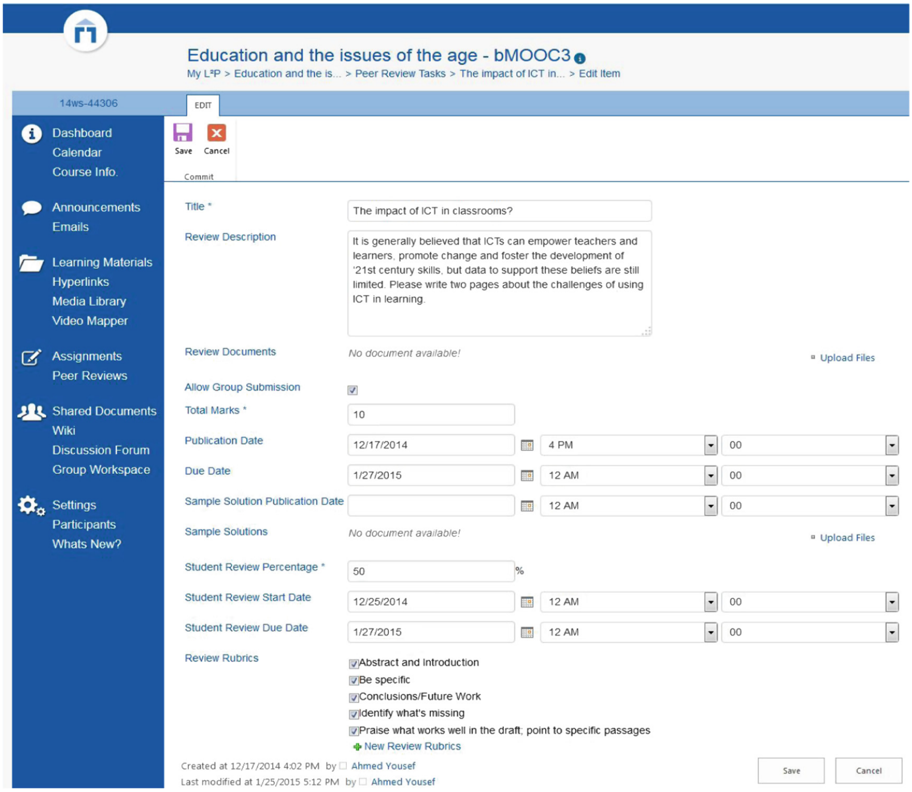

Fig. 7. Task definition with rubrics.

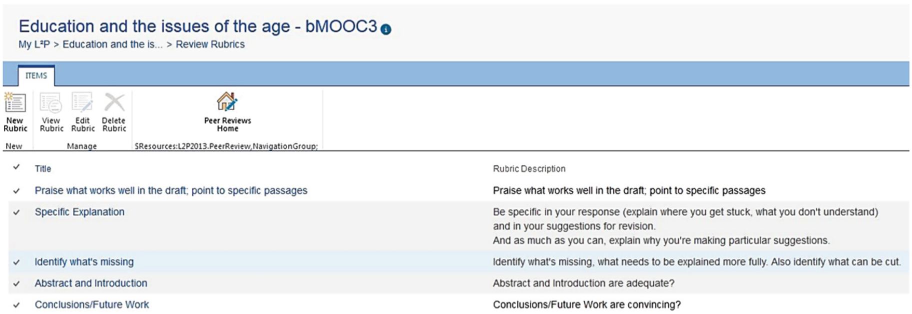

Fig. 8. Managing rubrics.

Once the assignment task has been defined, an automated workflow takes care of publishing the assignment at the specified time along with submission deadline. Meanwhile, another workflow takes care of the review submission after the review start date.

5.1.2 Assigning Reviewers

Course teachers can use this feature to assign solutions submitted by learners to different learners for reviewing. Teachers can simply select a learner from a list and assign any solution to him or her for review as shown in Fig. 9, future possibility to upgrade the system would be to automate the distribution process. There are mechanisms to reverse the process, if there is a problem or a mistake. After this, the assigned reviews are visible to the learners according to the specified dates, and if any review assignment is made after the review start date, it would be shown to the learners directly.

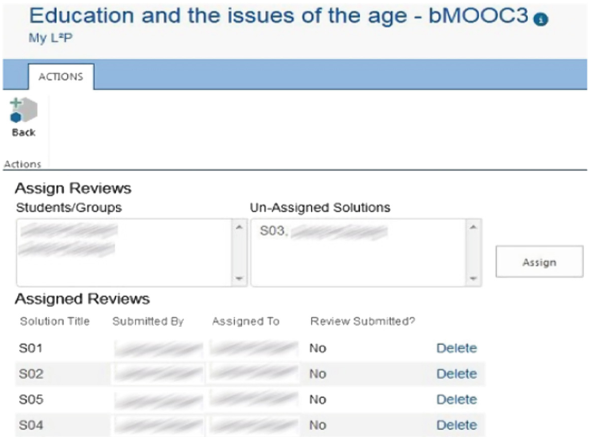

Fig. 9. Assigning reviewers.

5.1.3 Teacher Grading

Teachers have the option to grade the submitted solutions, but this is not mandatory. They could only assign a grade to learners taking the peer reviews into account, as shown in Fig. 10.

5.1.4 Publishing Grades

After grading all the solutions, teachers can publish the results to the learners at once using an action from the ribbon. As a result, the learners are able to see the correction from the teachers as well as the reviews submitted by their peers.

5.2 Learner Perspective

The navigation ribbon encompasses actions to help learners to submit solutions and perform the peer assessment task.

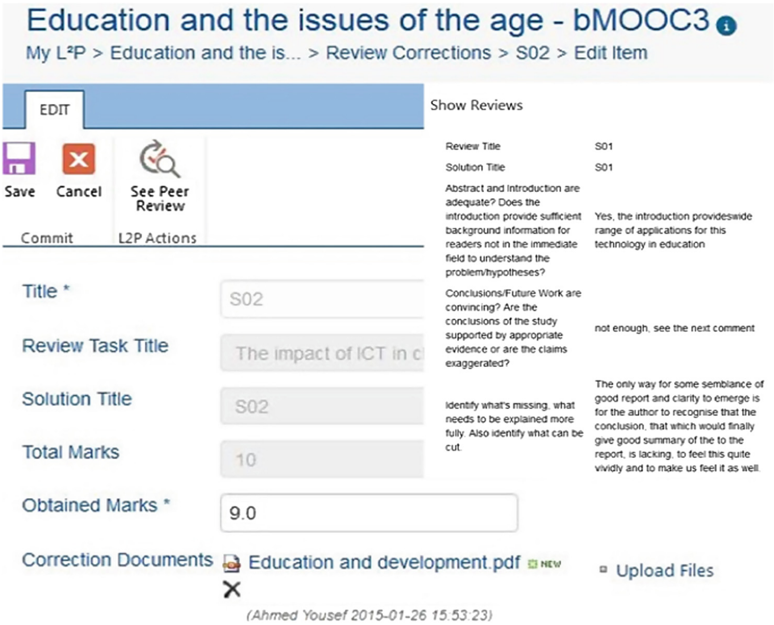

Fig. 10. Teacher grading.

5.2.1 Submitting Solutions

Once the assignment has been published, the learners can see the details of the assignment and work on their solutions until the proposed deadline. Learners can add a solution by adding a description and uploading their documents and resources relevant to the solution. Learners can work individually, or in groups, depending on the assignment's requirements (see Fig. 11).

5.2.2 Peer Assessment (Review)

There are a number of peer assessment methodologies dealing with the anonymity of author and reviewer, e.g. Single Blind Review (reviewer is anonymous, author is known), Double Blind Review (Both reviewer and author are anonymous) and lastly the Open Review (No anonymity). For the purpose of this implementation we decided to use the Double Blind Review, as it reduces the chances of biased marking [32].

Once the peer review phase starts, the learners can see a list of reviews assigned to them by the teachers. The interface for adding a review can be seen in Fig. 12. It contains two sections, the submitted solution on the top and the review section with rubrics at the bottom. The reviewers can see the documents and resources attached to the solution and any comments given by the authors. They can add their comments against the rubric questions in the review section along with an option to upload any files and grade the review as well.

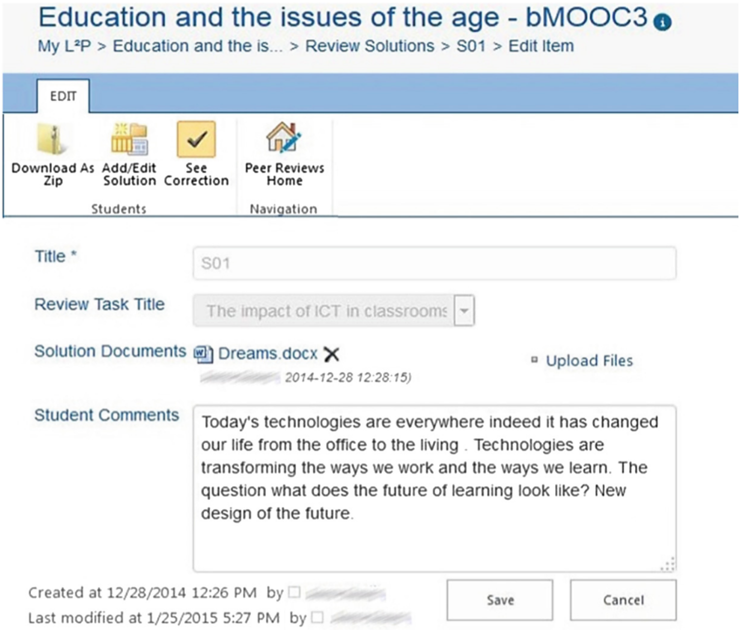

Fig. 11. Submitting solutions.

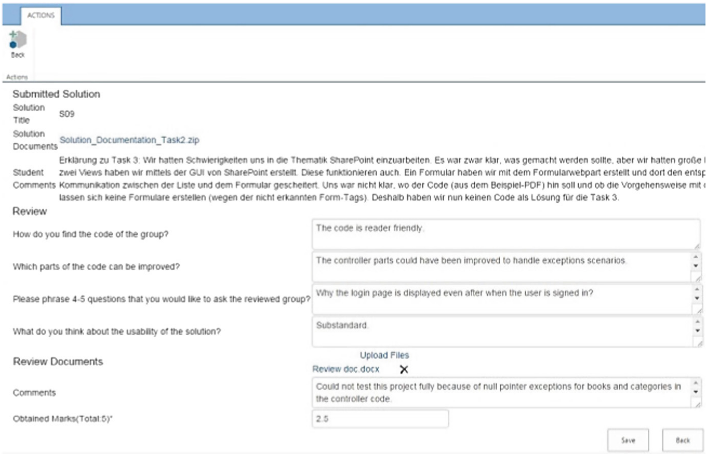

Fig. 12. Peer assessment (review) interface.

6 Case Study

In October 2014, we conducted a third case study to investigate the usability and effectiveness of the peer assessment module. We used the enhanced edition of L^{2}P-bMOOC to offer a bMOOC on “Education and the Issues of the Age” at Fayoum

University, Egypt in cooperation with RWTH Aachen University. The course was offered both formally to students from Fayoum University and informally with open enrollment to anyone who is interested in teaching and educations issues. The teaching staff is composed of one professor and one assistant researcher from Fayoum University as well as one assistant researcher from RWTH Aachen University. A total of 133 participants completed this course. 92 are formal participants who took the course to earn credits from Fayoum University. These participants were required to complete the course and obtain positive grading of assignments. The rest were informal participants who didn't attend the face-to-face sessions. They have undertaken the learning activities at their own pace without receiving any type of academic credits. The teaching staff provided nine short video lectures and the course participants added another 25 related videos. Participants in the course were encouraged to use video maps to organize their lectures, and collaboratively create and share knowledge through annotations, comments, discussion threads, and bookmarks. Participants used the peer assessment module for the submission of a team project report. After the submission, every team reviewed other's work and provided their feedback based on the rubric questions provided by the teaching staff. These reviews were then taken into consideration by the teaching staff while compiling their own feedback of the team projects. Once the teacher reviews were completed the final corrections were made public to the students who could see both reviews for their own project namely, the review from peer and the review from the teacher.

7 Evaluation

This case study, therefore, conducted a thorough evaluation of the peer assessment module in L^2P-bMOOC in order to answer the main research questions in this work. The aim was to evaluate the usability and effectiveness of the module, including the impact on learning outcome and the quality of feedback. Our endeavor was also to investigate which peer assessment model fits best in a bMOOC context. We employed an evaluation approach based on the ISONORM 9241/110-S as a general usability evaluation as well as a custom questionnaire to measure the effectiveness of peer assessment in L^2P-bMOOC.

7.1 Usability Evaluation

The purpose of usability evaluation is to measure learner's satisfaction with the peer assessment module as well as to identify the issues for improvement. The ISONORM 9241/110-S questionnaire was designed based upon the International Standard ISO 9241, Part 110 [29]. We used this questionnaire as a general usability evaluation for the peer assessment module. It consists of 21 questions classified into seven main categories. Participants were asked to respond to each question scaling from (7) a positive exclamation and its mirroring negative counterpart (1).

The questionnaire comes with an evaluation framework that computes several aspects of usability to a single score between 21 and 147. A total of 57 out of 133

Table 2. ISONORM 9241/110-S evaluation matrix (N = 57).

Factor	Aspect	Mean	Sum
Suitability for tasks	Integrity	5.2	15
	Streamlining	5.5	
	Fitting	4.3	
Self- descriptiveness	Information content	4.9	14.5
	Potential support	4.8	
	Automatic support	4.9	
Conformity with user expectations	Layout conformity	4.7	14
	Transparency	4.7	
	Operation conformity	4.6	
Suitability for learning	Learnability	5.4	14.7
	Visibility	4.8	
	Deducibility	4.5	
Controllability	Flexibility	4.9	14.2
	Changeability	4.5	
	Continuity	4.8	
Error tolerance	Comprehensibility	4.7	13.5
	Correct ability	4.6	
	Correction support	4.2	
Suitability for individualization	Extensibility	4.0	13.2
	Personalization	4.3	
	Flexibility	4.9	
ISONORM score	**99.1**		

participants completed the questionnaire. A diversity in learner's age was exhibited by the evaluators, their ages ranging from 18 to 40+ years with almost 65 % of the evaluators being between the ages of 18 and 24. Around 70 % of the evaluators were Bachelors students, 17 % from Masters Courses and the remaining 12 % pursuing a PhD. All of them had taken one or more online courses. The results obtained from the ISONORM 9241/110-S usability evaluations are summarized in Table 2.

The overall score was 99.1 which translate to "Everything is all right! Currently there is no reason to make changes to the software in regards of usability" [29]. This result reflects a high level of user satisfaction with the usability of peer assessment module in L^2P-bMOOC.

7.2 Effectiveness Evaluation

This study has focused on peer assessment to support groups or individuals to review, grade and provide in-depth feedback for their peers, based on flexible rubrics. The effectiveness evaluation aims at investigating the impact on learning outcomes and the quality of feedback as well as identifying the best peer assessment models in bMOOCs (Fig. 13).

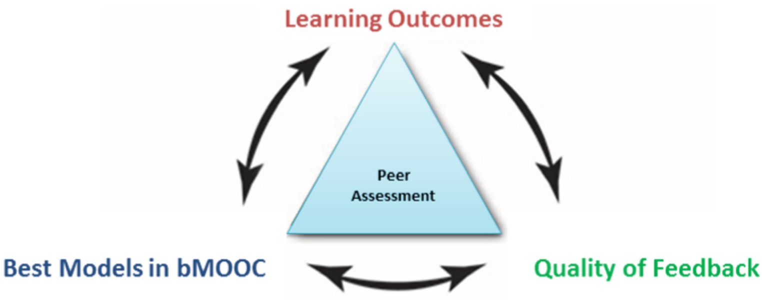

Fig. 13. Effectiveness evaluation dimensions.

This study included the design of a questionnaire adapted from [20, 36]. The questionnaire consisted of two main parts. The first part containing 21 items in the two categories mentioned above as illustrated in Table 3. The second part aimed at exploring the most effective peer assessment model in a bMOOC setting, as presented in Table 4. To ensure the relevance of these questions, a pre-test was conducted with 5 learners and 5 learning technologies experts. Their feedback included a refinement of some questions and replacing some others. The revised questionnaire was then given to the "Education and the Issues of the Age" course participants.

7.2.1 Impact on Learning Outcome

Respondents were asked to indicate whether the peer assessment has affected their learning outcome. As can be seen from Table 3, the overall response to the evaluation items 1–9 was very positive at 4.3 with acceptable standard deviation at 0.52. This indicates that peer assessment is a powerful evaluation method to detect and correct errors, reflect, and criticize which are key elements in double-loop learning. The concept of double-loop learning was introduced by Argyris and Schön [1] within an organizational learning context. According to the authors, learning is the process of detecting and correcting errors. Error correction happens through a continuous process of inquiry, reflection, and (self-) criticism, which enables learners to test, challenge, and eventually update their knowledge, and in so doing improving their learning outcome [3].

Peer assessment further fosters continuous knowledge creation, which is a prerequisite for effective learning [25]. This can be attributed to the fact that in the peer assessment process, learners can learn from either negative or positive aspects of peer's work and make use of them to get in-depth understanding of the learning topic and improve their knowledge, which leads to an enhancement of their learning performance.

7.2.2 Quality of Feedback

Key issues in peer assessment include the diversity of reviewers' background and prior experience [41], the lack of accuracy and credibility of peer feedback [33] as well as the lack of transparency of the review process. Moreover, MOOCs participants do not trust validity and reliability of peer assessment results due to the absence of a clear evaluation authority (e.g. teacher) and the low perceived expertise of students [22].

Rubrics provide a possible solution to overcome these issues by offering clear guidelines when assessing peer's work. Items 10 to 21 in Table 3 are concerned with the quality of the rubric-based peer feedback approach employed in L2P-bMOOC. In general, the respondents agreed that harnessing rubrics had a positive impact on the quality of the peer assessment task, in terms of the accuracy and credibility of peer feedback (item 11), transparency of the review process (item 20), as well as validity and reliability of peer assessment results (item 10 and 12). Moreover, the study revealed that participants became more confident in their ability to assess peers' work.

Table 3. The effectiveness evaluation of peer assessment in L^2P-bMOOC (N = 57).

No	Peer Assessment		
	Evaluation Items	**M**	**SD**
	Impact on learning outcome		
1	The peer feedback helped me to see errors in my own work.	4.5	0.50
2	Reviewing others' work helped me to reflect on my own work.	4.4	0.53
3	The received feedback helped me to reflect on my own work.	4.2	0.51
4	The peer assessment helped me to learn how to give constructive feedback to peers.	4.2	0.62
5	The peer feedback helped me to come up with new ideas.	4.4	0.53
6	The comments I received from peer feedback helped to improve the quality of my work.	4.3	0.48
7	The received feedback helped me to get more information about the learning topic.	4.4	0.53
8	Reviewing others' work helped me to expand knowledge about the learning topic.	4.3	0.51
9	The peer assessment increased my ability in organizing ideas and contents in my work.	4.1	0.50
	Impact on learning outcome average	**4.3**	**0.52**
	Quality of feedback		
10	The scoring grade I received from peer feedback was valid.	4.2	0.51
11	The peer feedback I received is accurate and credible.	4.2	0.50
12	I am confident that my peers have enough ability to assess my work.	4.2	0.53
13	I am confident that I have the ability to assess peers' work.	4.3	0.71
14	I put sufficient effort into grading peers' work.	4.5	0.56
15	The peer assessment rubrics and their descriptions were sufficiently clear.	4.3	0.57
16	The peer assessment rubrics supported in providing peers with detailed feedback on their assignment work.	4.4	0.62
17	The peer assessment rubrics assisted me in focusing on particular details in the peers work.	4.4	0.53
18	The description of the rubrics helped me understand what teachers expected in the evaluation report.	4.4	0.54
19	The peer assessment rubrics made the review task clearer.	4.4	0.56
20	The peer assessment rubrics made the review process more transparent.	4.3	0.54
21	The peer assessment rubrics were necessary to complete my review task.	4.4	0.53
	Quality of feedback average	**4.3**	**0.55**
	1. Strongly disagree … **5.** Strongly agree		

They confirmed that following clear rubrics helped them understand the evaluation criteria and supported them in providing peers with detailed feedback.

7.3 Peer Assessment Models

One important goal in our study was also to investigate which peer assessment model fits best in a bMOOC context, as presented in Table 4.

Table 4. Peer assessment models in bMOOCs.

Peer Assessment Models	Mean	SD
Time		
Early feedback	**4.6**	**0.50**
Delayed feedback	1.7	0.44
Anonymity		
Double blind review	**4.6**	**0.48**
Single blind review	2.3	0.61
Open review	1.7	0.88
Delivery		
Indirect feedback (i.e., written)	**4.6**	**0.72**
Direct feedback (i.e., face-to-face)	2.2	0.68
Peer Grading		
Review with grading	3.1	0.86
Review with partly grading	**4.4**	**0.79**
Review without grading	1.9	0.41
Peer Grading Weight		
Contributing to the final official grade	3.8	0.93
Not contributing to the final official grade	2.9	1.20
Channel		
Single channel feedback (1:1)	2	0.52
Multiple channel feedback (m:n)	**4.8**	**0.34**
Review Loop		
Single loop	2	0.73
Multiple loop	**4.8**	**0.34**
Teacher Role		
Substitution	2.1	0.57
Supplementary	**4.3**	**0.58**
Monitoring	2.9	0.87
1. Strongly disagree … **5.** Strongly agree		

From these results we can draw certain conclusions about the most effective peer assessment practices in bMOOCs as follows:

Time: Optimal feedback should be provided early in the assessment process in order to give learners the opportunity to react and improve their work.

Anonymity: An important aspect of peer assessment is to ensure the anonymity of the feedback. This way, reviewers can provide critical feedback and grading without considering interpersonal factors e.g. friendship bias or personal dislikes.

Delivery: Indirect feedback ensures more effective assessment results as learners feel more comfortable to give honest feedback without any influence from peers.

Peer Grading: Peer grading should only be a part of the final grade in order to ensure the validity of the assessment results.

Channel: Assessment results can be more accurate and credible when learners receive feedback from multiple reviewers rather than from a single one. This way, learners have the chance to receive a multifaceted feedback on their work.

Review Loop: Having multiple feedback iteration achieve a better learning outcome as learners can reflect on the assignment work multiple times.

Teacher Role: The teachers should still take an active role in the peer assessment process, by defining evaluation rubrics, providing sample solutions, and checking the peer review results.

8 Conclusion and Future Work

Massive Open Online Courses (MOOCs) have a remarkable ability to expand access to a large scale of participants worldwide, beyond the formality of the higher education systems. MOOCs use traditional assessment methods include, e-tests, quizzes, multiple-choice and short answer questions. These assessment tools are limited in evaluating learners in open and distributed MOOCs effectively. The main aim of this work was to determine how to assess the learners' performance in MOOCs beyond traditional automated assessment methods. Peer assessment has been proposed as an effective assessment method in MOOCs to address this challenge. Although peer-assessment is helpful to strengthen the learners' self-confidence and improve their own performance, this type of assessment was not widely used in the reviewed studies, mainly due to issues related to the lack of transparency of the review process as well as the lack of validity and reliability of the assessment results. In the paper at hand we presented the details of a study conducted to investigate peer assessment in bMOOCs. The study results show that flexible rubrics have the potential to make the feedback process more accurate, credible, transparent, valid, and reliable, thus ensuring the quality of the peer assessment task. Furthermore, early feedback, anonymity, indirect feedback, peer grading as only a part of the final grade, multiple channel feedback, multiple feedback loops, as well as a supplementary teacher role are the most effective assessment methods in bMOOCs.

However, each of the research questions followed in this study yields immediate, open research gaps that still exist, which should be considered for future work, especially: (a) improve grading accuracy and (b) understand which peer assessment scenarios affect learning outcomes in bMOOCs and how these scenarios can be supported.

Recent evidence suggests inter-rater reliability to measure the extent of agreement among raters as a possible solution for improving grading accuracy. In order to develop a full version of peer assessment, additional studies are needed that consider several promising scenarios such as (a) variation in the peer assessment loops (b) variation in the review channels e.g. peer assessment could take place in pairs or groups, (c) variation in the peer feedback e.g. written vs. oral feedback, (d) variation in the pedagogical anatomy e.g. anonymous vs. open, and (e) variation in assessment tasks e.g. formative assessment vs. summative assessment.

References

1. Argyris, C., Schon, D.: Organizational Learning: A Theory of Action Approach. Addision Wesley, Reading (1978)
2. Bruff, D.O., Fisher, D.H., McEwen, K.E., Smith, B.E.: Wrapping a MOOC: Student perceptions of an experiment in blended learning. MERLOT J. Online Learn. Teach. **9**(2), 187–199 (2013)
3. Chatti, M.A., Jarke, M., Schroeder, U.: Double-loop learning. In: Encyclopedia of the Sciences of Learning, pp. 1035–1037 (2012)
4. Chatti, M.A.: The LaaN theory. In: Personalization in Technology Enhanced Learning: A Social Software Perspective, pp. 19-42. Shaker Verlag, Aachen, Germany (2010)
5. Chatti, M.A., Lukarov, V., Thüs, H., Muslim, A., Yousef, A.M.F., Wahid, U., Greven, C., Chakrabarti, A., Schroeder, U.: Learning analytics: challenges and future research directions. eleed, iss. 10 (2014). (urn:nbn:de:0009-5-40350)
6. Clow, D.: MOOCs and the funnel of participation. In: Proceedings of the Third International Conference on Learning Analytics and Knowledge, pp. 185–189. ACM (2013)
7. Coursera: How will my grade be determined?. http://help.coursera.org/customer/portal/articles/1163304-how-will-my-grade-be-determined. Accessed 20 January 2015
8. Daniel, J.: Making sense of MOOCs: musings in a maze of myth, paradox and possibility. J. Interact. Media Educ. **3** (2012)
9. Davis, H., Dikens, K., Leon-Urrutia, M., Sanchéz-Vera, M.M., White, S.: MOOCs for Universities and learners an analysis of motivating factors. In: Proceedings of CSEDU 2014 Conference, pp. 105–116. INSTICC (2014)
10. Díez, J., Luaces, O., Alonso-Betanzos, A., Troncoso, A., Bahamonde, A.: Peer assessment in MOOCs using preference learning via matrix factorization. In: NIPS Workshop on Data Driven Education, December 2013
11. edX: Open Response Assessments. http://edx-guide-for-students.readthedocs.org/en/latest/SFD_ORA.html. Accessed 20 January 2015
12. Ghadiri, K., Qayoumi, M.H., Junn, E., Hsu, P., Sujitparapitaya, S.: The transformative potential of blended learning using MIT edX's 6.002 x online MOOC content combined with student team-based learning in class. Environment **8**, 14 (2013)
13. Gielen, S., Dochy, F., Onghena, P., Struyven, K., Smeets, S.: Goals of peer assessment and their associated quality concepts. Stud. High. Educ. **36**(6), 719–735 (2011)
14. Gielen, S., Peeters, E., Dochy, F., Onghena, P., Struyven, K.: Improving the effectiveness of peer feedback for learning. Learn. Instr. **20**(4), 304–315 (2010)
15. Totschnig, M., Willems, C., Meinel, C., Grünewald, F.: Designing MOOCs for the support of multiple learning styles. In: Hernández-Leo, D., Ley, T., Klamma, R., Harrer, A. (eds.) EC-TEL 2013. LNCS, vol. 8095, pp. 371–382. Springer, Heidelberg (2013)

16. Hill, P.: Some validation of MOOC student patterns graphic (2013). http://mfeldstein.com/validation-mooc-student-patterns-graphic/
17. Jordan, K.: MOOC completion rates: The data (2013). http://www.katyjordan.com/MOOCproject. Accessed 20 January 2015
18. Kaplan, F., Bornet, C.A.M.: A preparatory analysis of peer-grading for a digital humanities MOOC. In: Digital Humanities 2014: Book of Abstracts no. EPFL-CONF-200911, pp. 227–229 (2014)
19. Kop, R., Fournier, H., Mak, J.S.F.: A pedagogy of abundance or a pedagogy to support human beings? Participant support on massive open online courses. Int. Rev. Res. Open Distance Learn. **12**(7), 74–93 (2011)
20. Kulkarni, C., Wei, K.P., Le, H., Chia, D., Papadopoulos, K., Cheng, J., Koller, D., Klemmer, S.R.: Peer and self assessment in massive online classes. ACM Trans. Comput. Hum. Interact. (TOCHI) **20**(6), 33 (2013)
21. Luo, H., Robinson, A.C., Park, J.Y.: Peer Grading in a MOOC: reliability, validity, and perceived effects. Online Learn. Official J. Online Learn. Consortium **18**(2) (2014)
22. McGarr, O., Clifford, A.M.: 'Just enough to make you take it seriously': exploring students' attitudes towards peer assessment. High. Educ. **65**(6), 677–693 (2013)
23. McMullan, M., Endacott, R., Gray, M.A., Jasper, M., Miller, C.M., Scholes, J., Webb, C.: Portfolios and assessment of competence: a review of the literature. J. Adv. Nurs. **41**(3), 283–294 (2003)
24. Nielsen, J.: Usability inspection methods. In: Conference Companion on Human Factors in Computing Systems, pp. 413–414. ACM (1994)
25. Nonaka, I., Takeuchi, H.: The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University Press, Oxford (1995)
26. Ostashewski, N., Reid, D.: Delivering a MOOC using a social networking site: the SMOOC design model. In: Proceedings of IADIS International Conference on Internet Technologies and Society, pp. 217–220 (2012)
27. O'Toole, R.: Pedagogical strategies and technologies for peer assessment in massively open online courses (MOOCs). Discussion Paper, University of Warwick, Coventry, UK (2013). http://wrap.warwick.ac.uk/54602/
28. Piech, C., Huang, J., Chen, Z., Do, C., Ng, A., Koller, D.: Tuned models of peer assessment in MOOCs (2013). arXiv preprint arXiv:1307.2579
29. Prümper, J.: Der Benutzungsfragebogen ISONORM 9241/10: Ergebnisse zur Reliabilität und Validität. In: Software-Ergonomie 1997, pp. 253–262. Vieweg+Teubner Verlag (1997)
30. Sánchez-Vera, M.M., Prendes-Espinosa, M.P.: Beyond objective testing and peer assessment: alternative ways of assessment in MOOCs. RUSC Univ. Knowl. Soc. J. **12**(1), 119–130 (2015). doi:http://dx.doi.org/10.7238/rusc.v12i1.2262
31. Sandeen, C.: Assessment's place in the new MOOC world. Res. Pract. Assess. **8**(1), 5–12 (2013)
32. Sitthiworachart, J., Joy, M.: Effective peer assessment for learning computer programming. In: ACM SIGCSE Bulletin, vol. 36, no. 3, pp. 122–126. ACM (2004)
33. Suen, H.K.: Peer assessment for massive open online courses (MOOCs). Int. Rev. Res. Open Distance Learn. **15**(3) (2014)
34. Topping, K.: Peer assessment between students in colleges and universities. Rev. Educ. Res. **68**(3), 249–276 (1998)
35. Van Zundert, M., Sluijsmans, D., Van Merriënboer, J.: Effective peer assessment processes: research findings and future directions. Learn. Instr. **20**(4), 270–279 (2010)
36. Wolf, K., Stevens, E.: The role of rubrics in advancing and assessing student learning. J. Effective Teach. **7**(1), 3–14 (2007)

37. Yin, S., Kawachi, P.: Improving open access through prior learning assessment. Open Praxis **5**(1), 59–65 (2013)
38. Yorke, M.: Assessment, especially in the first year of higher education: old principles in new wrapping. In: REAP International Online Conference on Assessment Design for Learner Responsibility (2007)
39. Yousef, A.M.F., Chatti, M.A., Ahmad, I., Schroeder, U., Wosnitza, M.: An evaluation of learning analytics in a blended MOOC environment. In: The European MOOC Stakeholder Summit 2015 (2015a Submitted)
40. Yousef, A.M.F., Chatti, M.A., Danoyan, N., Thüs, H., Schroeder, U.: An evaluation of learning analytics in a blended MOOC environment. In: The European MOOC Stakeholder Summit 2015 (2015b Submitted)
41. Yousef, A.M.F., Chatti, M. A., Wosnitza, M., Schroeder, U.: A cluster analysis of MOOC stakeholder perspectives. RUSC Univ. Knowl. Soc. J. **12**(1), 74–90 (2015c)
42. Yousef, A.M.F., Chatti, M.A., Schroeder, U., Wosnitza, M.: A usability evaluation of a blended MOOC environment: an experimental case study. In: The International Review of Research in Open and Distributed Learning, (2015d, Accepted)
43. Yousef, A.M.F., Chatti, M.A., Schroeder, U., Wosnitza, M., Jakobs, H.: MOOCs - a review of the state-of-the-art. In: Proceedings of CSEDU 2014 Conference, vol. 3, pp. 9–20. INSTICC, 2014 (2014a)
44. Yousef, A.M.F., Chatti, M.A., Schroeder, U., Wosnitza, M.: What drives a successful MOOC? an empirical examination of criteria to assure design quality of MOOCs. In: 14th IEEE International Conference on Advanced Learning Technologies Proceedings. ICALT 2014, pp. 44–48 (2014b)

Quantifying and Evaluating Student Participation and Engagement in an Academic Facebook Group

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Abstract. Asynchronous online discussions offer many advantages in an educational context such as building a class community, empowering students to express themselves, facilitating exploratory learning and contributing to the development of cognitive, critical thinking and writing skills. Whether integrated within a Learning Management System or as an external website, one of the most common platforms for hosting such asynchronous online discussions is a discussion board. Recent technological advancements, however, offer a wide number of alternative tools. Among them, the 'Groups' feature from Facebook, currently the largest online social network, has attracted a lot of attention by the academic community and ample research demonstrates the benefits of the specific tool for educational purposes. Comparing Facebook Groups with a discussion board in terms of support for the instructor to appraise student participation and engagement reveals a drawback for Facebook Groups. While discussion boards are supported by a number of learning analytics tools, no such academic support seems to exist for a Facebook Group. In this paper we introduce InGauge, a novel educational tool that enables instructors to gauge the level of student engagement and participation within an academic Facebook group. Founded on educational theories for evaluating online engagement, InGauge can collect and analyse all activities within the group and generate a number of learning analytics reports. The most important academic feature, however, is that InGauge offers support for customizing an assessment model in order to meet the student participation requirements of any type of Facebook group that is used for educational purposes.

Keywords: Facebook groups · Measuring engagement · Student participation

1 Introduction

Engagement in discussion is considered a fundamental aspect in the constructivism learning theory, through which students can generate knowledge and meaning based on interactions with other learners and the environment [1]. Having as main benefits the increased engagement with the learning content, as well as, the development of high-order thinking and divergent thinking [2], one can safely accept that active engagement in discussions may contribute to the learning process and can facilitate the overall

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learning experience. Since opportunities for learners to engage in discussion within a classroom setting is limited due to logistical and psycho-sociological factors [3], the use of online asynchronous discussion boards has long been established as a common method in engaging students in discussion beyond classroom hours. Such tools, frequently integrated within Learning Management Systems, can be utilised as a support mechanism to face-to-face teaching or within an authentic online learning setting. Realizing the teachers' needs for evaluating participation in online discussions, as well as, the learners' needs for motivation in order to participate, a wide number of methods and tools are being used in order to measure participation and engagement both in terms of quantity and quality.

Despite the success of online discussion forums, recent advances in Web 2.0 technologies and social networks, and most importantly, their wide adoption by students, led teachers to seek contemporary and more attractive ways of engaging students in online discussions [4]. Facebook, and more precisely its "Closed Facebook Groups" feature, is becoming a common platform for hosting online discussions gradually replacing old forums and collaboration capabilities of Learning Management Systems [5]. In fact, research studies [6, 7] have shown that students prefer Facebook compared to other alternatives for hosting online discussions, mainly because of the comfort they feel when engaging with Facebook as a platform.

In this paper we introduce InGauge, a novel online application that addresses the issue of measuring student engagement in academic discussions hosted in a Facebook group. Grounded on educational theories of measuring participation in online discussions, the system enables instructors to effortlessly extract and summarise all contributions and activities of the group members and to evaluate the levels of engagement both in terms of quantity and quality. InGauge also empowers instructors to configure a custom contribution evaluation model according to their respective academic requirements for a Facebook group in order to suitably quantify and measure the engagement level of students. Last but not least, InGauge can provide insights on student engagement with specific learning content since a teacher can associate topics and issues to be discussed in the group to specific time periods.

The rest of the paper is organised as follows. In Sect. 2 we formulate a theoretical background in order to justify the rationale for the need of the InGauge system. The topics examined include the pedagogical values of asynchronous online discussions and the use of traditional discussion forums, the importance of measuring engagement in online discussions and finally the use of Facebook groups as a platform to host academic online discussions. In Sect. 3 we introduce InGauge. We start by elaborating on the pedagogy and motivation behind the system and continue to present a high level description of the components and offered functionality. Section 4 discusses the current state of the system and suggests possible uses to instructors. Finally, the last section concludes and presents future work.

2 Background Issues

Constructivism is one of the most cited and appealing theories related to education in the recent years [1]. According to the constructivism theory, students are seen as active learners that create meaning and construct knowledge through active engagement with the conceptual content using strategies such as talking in complement to listening, writing in complement to reading, interaction, problem solving and similar active learning approaches [8]. The classroom setting, according to constructivism, is considered a knowledge building community rather than a group of isolated students that listen to the input of the lecturer [1] and classroom discussion, being the most fundamental 'active' learning approach, is considered to be a crucial aspect of the learning process [9]. The role of internal and interactive dialogue in knowledge construction was explored by [2] and emphasised the importance of what is called the 'conversational model of learning'. Among the most important benefits are increased engagement in the learning task, elevated levels of motivation, development of high-order learning skills and divergent thinking [2]. Nevertheless, actively participating in classroom discussions and interacting with the instructor and peers can be challenging for a student. While there exist many logistical or psycho-sociological factors that negatively affect active participation in the classroom [3], two have been identified as the most important ones to students. The first factor is lack of participation opportunity [10]. It is easily understood that in classes with a large number of students participation naturally decreases, considering that giving each student the opportunity to participate would cause time management issues [11]. The second factor is fear of peer disapproval [12]. Students may fear that peers will silently disapprove and resent their monopolization of classroom discussion, or that they may appear unintelligent to others, in case of mistakes. Because, however, of the importance of participation in discussions in the learning process, technological solutions have been developed to enable learners to interact and discuss even in an asynchronous mode.

2.1 Asynchronous Online Discussions and Their Advantages

Asynchronous online discussion environments, frequently called discussion boards or forums, have been used by academics for many years. Such environments are often integrated within online Learning Management Systems such as Blackboard and Moodle. Many universities have integrated asynchronous online discussions in their course curriculum realizing the benefits that they offer to students for active engagement with peers and instructors.

One of the main advantages offered by asynchronous online discussions is that they provide an equal opportunity for all students to engage in conversational activities. They allow students that need time in order to participate to have the same possibilities with other classmates [9]. They also create better possibilities for introvert or shy students to be an active part of the discussion [1], as well as, for non-native students who may be reluctant to participate in classroom discussions mainly due to linguistic problems [13]. Online discussion boards are a popular medium for these types of students to overcome their limitations, and at the same time, improve their communication and writing skills [14]. A second important advantage of asynchronous online discussions is that they provide participants more time to reflect on their thoughts before they formalise their contribution [15]. More time to reflect means that a student has the opportunity to examine a topic in more depth compared to a synchronous environment which demands the continuous input of the participants [14, 16]. Due to the elimination of time constraints the learning process is significantly enhanced [17] since students are cognitively engaged by actively constructing knowledge through reflective explorations of ideas, conclusion drawing, and synthesizing these conclusions in the form of contribution to the discussion. Finally, a third very significant advantage of online asynchronous discussions is flexibility. They make the class accessible twenty-four hours a day, seven days a week, and allow students to engage and participate at their own pace. This flexibility in engaging with the course content and peers is greatly appreciated by learners and is used extensively for presenting their ideas as well as critically evaluate those of others [18].

Due to the aforementioned advantages, instructors are extensively integrating asynchronous online discussions as a supplement to face-to-face discussions of a conventional classroom setting [19]. Regarding the online platforms, however, that host such asynchronous online discussions, a shift is observed due to the recent advancements of web 2.0 technologies. While online discussion forums are still offered within Learning Management Systems, many universities are increasing their flexibility by promoting new possibilities of discussion outside the classroom through social media [14]. In other words, there seems to be an unequivocal upward trend into shifting online discussions to social networking platforms, primarily because of the fact that such social platforms are widely used by students.

2.2 Facebook Group: A Platform for Hosting Asynchronous Online Discussions

Social networking sites have become a common part of everyday life and this effect is more common on young adults and students [20]. The most popular online social network nowadays is Facebook [21]. Considering official data distributed by Facebook itself, there are 1.49 billion monthly active users on the site and more than 968 million daily active users as of June 2015 [22]. Moreover, an increasing usage of Facebook from mobile devices is being recorded, with more than 1.25 billion active daily users accessing from their mobile devices [22]. Especially the young adult age group seems to devote a considerable amount of time to social networking through Facebook, a fact that has altered the way of communication and social interaction [23] and has also affected campus life [24]. Realizing the huge popularity of Facebook and the fact that the vast majority of students do spend a lot of time on it, researchers and educators attempt to take advantage of this reality and continuously seek ways to exploit Facebook for learning and teaching purposes. After all, a platform where students continuously show high levels of engagement is believed to have the potential to promote active learning and collaboration between students [25] and may provide opportunities for forming communities for educational purposes [26]. In the context of asynchronous online discussions, the “Facebook Group” is the feature which has the potential for substituting the traditional online discussion forums built inside common Learning Management Systems, such as Blackboard or Moodle [5, 25].

Facebook groups as an instrument to accommodate asynchronous online discussions for academic purposes in order to supplement traditional face-to-face teaching has been explored by a number of research studies such as [27–30] with very positive outcomes.

In a case study [6] investigating the usage of the Blackboard discussion board compared to a Facebook Page used for academic purposes determined that Facebook proved to be the preferred discussion medium for the majority of students. In a similar study [31], a nearly 400 % higher usage rates were observed on the Facebook Group, compared to WebCT discussion board. The success of Facebook groups over traditional forums integrated inside LMSs is mainly related to the comfort and convenience that students feel when using a platform which they very frequently use in their everyday life [32, 33]. As stated in [4], by "meeting students at their place", the likelihood that they will be more motivated to engage with other peers and course content is increased. Overall, students seem to favor the use of a Facebook group for academic purposes [27, 30] and recognise it as a valuable medium for hosting online discussions [33, 34]. They perceive it as a dynamic learning environment that properly supports collaborative learning processes but also as a stimulator for participation [29] that can greatly increase the engagement level of student activities [28].

In the aforementioned research studies, the Facebook groups were created and administered by instructors primarily to supplement traditional face-to-face teaching. However, there are also examples of students themselves creating Facebook groups in order to have asynchronous online discussions with classmates in a pure e-learning setting such as in Massive Open Online Courses [35]. Whether as a supplement to traditional face-to-face teaching or used solely in an e-learning setting, Facebook groups has the potential to increase the participation and engagement of students compared with traditional discussion forums.

2.3 Measuring Engagement in Asynchronous Online Discussions

In order to actively participate in an online discussion, students need to be motivated to do so [7]. Unarguably, within an academic setting, an apparent form of motivation is to formally assess the volume and quality of interaction in online discussions as a component of a unit's final mark. Extensive research actually suggests that a successful online discussion is directly related with its assessment [36–38]. In order to be able to assess students' online participation, it is necessary to identify, measure and evaluate each individual contribution of each learner in the discussion forum. Moreover, this evaluation is essential also as a form of feedback to students regarding their performance in the group collaboration [2].

A successful evaluation of students' engagement in online discussions should take under consideration both the quantity and quality of contributions, since a large number of posts does not necessarily signify high levels of critical thinking or cognitive engagement. Regarding qualitative analysis of online discussion messages, a number of frameworks and methods have been developed such as the Moderators Assessment Matrix [39] or Gricean cooperative principle theory [40] and even data mining techniques. Nevertheless, the overall complexity and the time required by an instructor, to measure the levels of cognitive engagement by looking for specific patterns according to a set of theories, may inhibit the wide adoption of such qualitative appraisal techniques. On the other hand, only using quantitative evaluation methods may yield misleading results in terms of student engagement. Research has shown that students tend to learn quickly to play 'the game of assessment' where they post only to get the marks, but their postings are superficial and lack in quality and critical thinking [41, 37]. In order to overcome this problem, [37] acknowledge the reaction of other students to a posting as a direct quality indicator, and as one of the most important forms of qualitative evaluation. Contributions that stimulate a lot of interaction and responses by other students rank higher in quality compared to contributions that fail to engage other students [37] and, therefore, generated interaction can be considered as a form of automatic peer review. Furthermore, [42, 43] suggest that both the individual, as well as, the group overall should be evaluated. According to them, collaboration is a complicated activity that requires both individual and group effort. Therefore, in order to achieve successful cooperative learning, both the group and the individual must be assessed. A simple, frequently used scheme is having group members assessing contributions of their peers, who take then an average individual grade [37]. Assessing based on the number of responses or interaction generated can be thought as an automatic way of receiving peer review from group peers.

Learning Management Systems which incorporate online discussion forums usually offer tools for measuring students' engagement in online discussions. Blackboard, a proprietary LMS, offers a performance dashboard through which an instructor can view discussion board statistics and accordingly grade the student engagement and performance. Moodle, an open source LMS, offers similar functionality with the Participation-Forum plugin but also provides advanced insights in student engagement through plugins like BushGrapher and Snapp 1.5 which can visually represent discussion forum activity and relationships. Nevertheless, as discussed in Sect. 2.2, the Facebook groups feature is gaining momentum as the platform to host asynchronous online discussions for educational settings. A thorough research that has been carried out revealed no educational tool that addresses the issue of measuring student participation in a Facebook group. There exists only one system which is called Grytics [44] that was launched in spring 2015. While Grytics provides a wide number of analytics for Facebook groups, it is mostly targeted towards companies and does not offer parameterization for academic purposes. Lastly, it requires payment and the free-of-charge plan only analyses the last fifty posts within a Facebook group. Therefore, to the best of our knowledge, the InGauge system presented in this paper is the first free educational tool that offers the ability to evaluate student participation and engagement for online asynchronous discussions which are hosted in a Facebook group.

3 InGauge: An Engagement Analytics Tool for Academic Facebook Groups

InGauge is a pioneering web-based application that addresses the issue of measuring student engagement within an academic Facebook group. Grounded on educational theories regarding measuring engagement in online discussion forums, InGauge (main dashboard depicted in Fig. 1) offers instructors a number of ways not only to realise and appropriately evaluate student and group participation, but also the means to identify learning content that may require attention.

Fig. 1. InGauge main dashboard.

The following sections discuss the pedagogy and motivation behind the InGauge system, provide a high level description of the offered academic parameterization and present the learning analytics that can be generated. We also briefly discuss development and performance issues.

3.1 Motivation and Pedagogy

A number of research studies [36–38] have revealed that successful online discussions are directly related with the assessment of a course and that many learners need an incentive to participate in class discussions [9]. However, several other studies [18, 19] support the opposite and have concluded that although students are largely in favor of online discussions, they prefer the contribution to be voluntary. Whether assessed or not, research studies [13, 45] have shown that participation in online asynchronous discussions is a good predictor of students' achievements and final marks, and a correlation between participation in online discussions and students' grades has been identified. For example, one study [46] determined that students with high marks were more actively engaged in the unit's discussion forum. Furthermore, another study [47] concluded that students that had a higher degree of participation in online discussions submitted more complete assignments compared with students who had a lower level of interaction. It can thus be concluded that the ability to measure participation and engagement in online group discussions can assist instructors in estimating student performance.

As already mentioned, while the Facebook groups feature is capturing a lot of attention by academics as a platform to host asynchronous online discussions between learners, an extensive research that was conducted revealed that there is no educational system that provides any kind of analytics for student participation in the group. After realizing this opportunity, we determined that academia uses Facebook groups for online discussions in numerous intermixable ways and with different supporting pedagogies. One approach is to use a Facebook group to supplement traditional face-to-face teaching. A Facebook group can also function in a pure online learning setting as the only means for students to collaborate and communicate. Another variation is that a Facebook group can be instructor initiated and administered whereas other groups are initiated and maintained solely by students. Finally, participation in group discussions may be either mandatory and assessed or voluntary and not assessed. All these alternative approaches of using a Facebook group for academic purposes had to be taken under consideration in order to provide a system that is flexible enough to cover the various needs of instructors, as well as, modular enough to adapt to the students' needs.

3.2 High Level Description of Ingauge Core

InGauge enables instructors to extract and summarise all students' activities within an academic Facebook group. An instructor must be the administrator of the specific Facebook group in order to have access to this data and all other functionalities offered by InGauge. After logging in with a Facebook account, InGauge can automatically detect all groups for which the logged on user acts as an admin, and, through a panel, offers the opportunity to select which group(s) will be analysed.

Within a Facebook group, the primary activities of the group's members that can currently be extracted and summarised include making a post, making a comment and 'liking' a post or a comment. By collecting and summarizing these activities, a member's participation in the group can be effectively measured since, higher frequency of such activities, suggest higher participation. A final activity that one can notice within a Facebook group is the 'seen' feature. The specific feature indicates which group members have seen a post or a comment. Seeing a post or a comment can still be considered as participation in a group even if it is passive (just viewing). The first version of InGauge, which was released in March 2015, used the specific feature as part of the algorithm that distinguishes the type of student participation and it was indeed very valuable. Unfortunately, the latest version of the Facebook API (v2.4 introduced in July 2015) deprecated the functionality of extracting the group members who have seen a post or a comment. As a result, we had to update our system and algorithms to only use the three aforementioned interactions namely making a post, making a comment and 'liking' a post or a comment. However, measuring this type of interactions within a group solely represents the quantity of the activities and cannot indicate anything about the quality of the contributions. As research suggests [48], one of the main indicators of the quality of a post is the interaction that it receives from other peers in the group. Within a Facebook group this interaction can be measured by extracting the comments and ‘likes’ that a post receives. This measurement, although quantitative in nature, evaluates the quality of a post in regards to participation. In summary, InGauge uses five variables overall, to measure student participation: posts, comments and ‘likes’ that a student contributes to the group, and finally, comments and ‘likes’ that a student’s contribution receives from peers in the group.

However, merely extracting and summing the aforementioned five types of activities in order to estimate student participation is not sufficient, even if both the quantity and quality dimensions are addressed. The reason is that, in this manner, all five types of activities are considered equivalent, which is clearly not the case. For example, a post or a comment should not have the same contribution value as a ‘like’ since posts and comments can be considered as active actions whereas a ‘like’ can be characterised as a passive one. In a similar frame of thinking, a student post that receives interaction (comments) from twenty peers may be indicated to have higher quality compared to a post that does not initiate interaction. When comparing comments and posts, it is evident that the difference in quality between the two is relative and cannot be easily evaluated. However, a post can be considered as the initial action for contributing to the group discussion, whereas a comment as reaction or response.

From all the above, a need rises for differentiating the value of each type of contribution. InGauge addresses this issue by incorporating a component called Contribution Evaluation Model. The specific evaluation model, depicted in Fig. 2 above, allows an instructor to configure the individual weight for making a post, making a comment and ‘liking’ a post or a comment. Regarding the quality aspect of a group member’s contribution (comments and likes that a post receives), an instructor does not have to directly set any weights. InGague uses the weights entered in the contribution evaluation model in a similar manner by giving emphasis on active rather than passive participation. More specifically, the weight of receiving a comment in a post is formulated by adding the weights set for making a new post and making a comment. Receiving has the same value (weight) as clicking like on a post. By combining the extracted number of activities with the weights set in the Contribution Evaluation Model, InGauge calculates a score that represents student participation by taking into account both qualitative and quantitative aspects.

Up until this point we have tackled the issue of measuring student participation within an academic Facebook group. Measuring engagement is far more complicated, and requires additional factors to be taken under consideration. As research suggests [48], in addition to points collected from participation, the frequency of active contributions is an important factor that is required in order to evaluate the level of engagement in comparison with peers and the group overall. For example, a student that has scored 100 points in participation in a period of one week, but then has no contribution in the following two weeks, cannot be considered to have the same engagement as a student who has scored a total of 100 points uniformly distributed within the duration of the three weeks. Another factor that we suggest should be taken under consideration and is implemented as an optional setting within the contribution evaluation model in InGauge is the expected participation performance for a specific period of time (Fig. 3 above). This setting enables an instructor to establish a margin between satisfactory and unsatisfactory performance for a group member in terms active participation (making posts

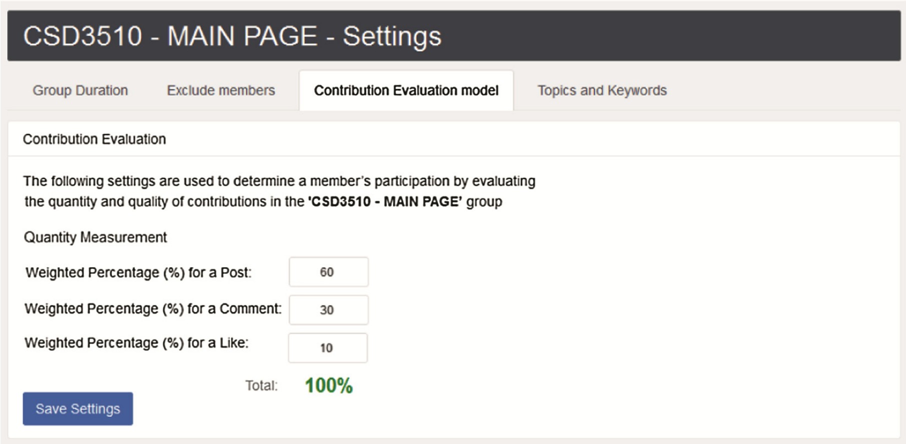

Fig. 2. Contribution evaluation model.

and comments). The pie chart within Fig. 1 is a learning analytic directly related with the specific setting as it allows the instructor to distinguish students who are passive (just 'liking' posts), students who are active but have not yet met the expected minimum performance and students who are highly active and are contributing much more than was expected.

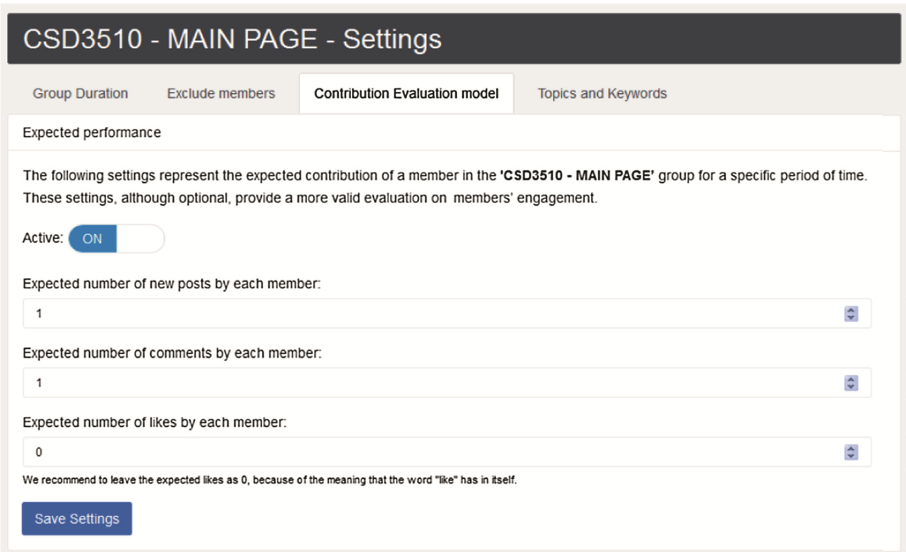

Fig. 3. Expected performance settings in InGauge.

The details of the student engagement calculation algorithm are quite complex and due to space limitations, the interested reader may refer to [49]. In summary, the algorithm that we developed takes under consideration the following parameters:

- The overall points obtained from active participation (quantity of contributions);
- The overall points obtained from receiving comments/likes and the number of unique engaged participants (quality of contributions);
- The overall points obtained by all other peers in the group for a selected time period of interest;
- The expected number of posts and comments per time unit set by the instructor;
- The time passed since the last post or comment of the student.

We strongly believe that InGauge not only is novel in addressing the issue of measuring student participation and engagement within an academic Facebook group, but does so in ways that are firmly grounded in educational theories regarding online discussions. In addition, since our goal was that InGauge will be used solely for educational purposes, we incorporated a number of settings that are mostly applicable in an academic environment. These settings include:

- The instructor can choose to exclude certain group members from the analytics. Since the participation of the members of the group affects the overall engagement of the group, there may be cases where certain members have to be excluded in order to have more valid analytics. Examples of such members include the instructor(s) and teaching assistants.
- The instructor can set the dates for the duration of the Facebook group (e.g. an academic semester) but also set dates for smaller academic periods (e.g. weekly lectures) for which analytics will be produced. For example, if a course is delivered on a Thursday, the instructor can set the weekly period from Thursday until next Wednesday as opposed to the default week setting of Monday to Sunday found in other systems.
- The instructor can provide keywords and tags for the weekly periods. These keywords can represent the topics that are being discussed in class during specific weeks. The instructor can then determine for which topics the students were more or less active in terms of participation in the group.

In summary, the settings that InGauge offers enable an instructor to set a custom assessment model that will evaluate student participation in the Facebook group but also provide features to parameterise the administration and monitoring of the group overall and the generated results in order to meet most requirements of the delivery of any academic course.

3.3 InGauge Learning Analytics

Learning analytics is defined in the current research as an emerging field [50] that employs different methods and techniques, such as machine learning, artificial intelligence, information retrieval, and data mining [50, 51] to improve learning and instruction mainly by revealing analytics about online student engagement to instructors

[52, 53] and/or learners [53]. There exist different types of learning analytics with different levels of importance. A recent study [54] explains that learning analytics software can benefit users at three different levels. The first is the most basic level. The data provided are related to access frequency, time spent in a course, and the number and nature of instructional interactions such as assessments (e.g. tests or exercises), content (e.g. articles, videos) and collaborative activities (e.g. discussions or blog posts). The second level is about providing more detailed data. These data are interpretations of students' instructional activities. For example, identifying at-risk students and warn the instructor about those students who haven't seen the exam material yet. These interpretations can also benefit from linking the instructional activities with students' data, such as gender, age, and major, to provide insights about learning patterns of cohorts of students. The third level analytics software can provide predictive data to predict students' behavior and learning patterns by linking the learning system database with the educational institution's information system and perform different methods and techniques to develop student outcomes alert systems and intervention strategies [4].

The learning analytics that InGauge provides are situated in levels one and two. It is easily understood that third level analytics are very difficult to be provided since Facebook is an external proprietary platform and cannot be easily integrated with an educational institution's information system or learning management system. In addition, even for level one and level two analytics there exist certain limitations due to the restrictions imposed by the Facebook API. For example, access frequency and time spent in a Facebook group cannot be determined and grouping analytics by gender or age may be inaccurate since they depend on the profile settings of each group member. The learning analytics offered by InGauge can be classified in two categories: overall analytics for the Facebook group and analytics for the individual members of the group. The overall analytics (Fig. 1) for the Facebook group include:

- The total number and percentage of posts, comments and likes
- The daily average number of posts, comments and likes
- A bar-chart distribution of posts, comments and likes
- A pie chart that distinguishes passive, active and highly active members
- Percentage of posts commented, liked and both commented and liked
- The average engagement score
- The average number of unique commenters

The first four analytics are related with the quantity of student participation whereas the last three are related with the quality. The analytics for the individual members of the group include:

- The total number of posts, comments and likes
- The average post quality
- The average unique commenters, comments per post, likes per post
- The total engagement score

As it can be seen in Fig. 4, the group members analytics are displayed in tabular format and can be easily sorted by any of the above scores in either ascending or descending manner in order to allow instructors to determine the most and least active students. It is also worth to note that the above analytics, as well as, the ones for the group overall, can be generated for custom periods of time (e.g. a specific academic week, or for the duration of the group).

10 records per page Search:

Name	Total Score	Posts	Comments	Likes	Average post quality	Avg. Uniq. Commenters	Avg. Comms. per Post	Avg. Likes per Post
Alexandra Cristina Pătraşcu	5.20	2	5	25	1.00	0.00	0.00	2.00
Alireth Shadowsing	1.50	1	2	3	2.00	0.00	0.00	4.00
Beren	8.00	5	8	26	1.70	0.00	0.00	3.40
Dragos Andriciuc	7.00	0	14	28	0.00	0.00	0.00	0.00
Edi Hoxhalli	4.60	2	7	13	0.25	0.00	0.00	0.50
Ilya Dobrodeev	0.00	0	0	0	0.00	0.00	0.00	0.00
Kosmas Theodoulidis	1.50	0	5	0	0.00	0.00	0.00	0.00
Lumbardh Idrizi	2.30	1	4	5	11.25	5.00	6.00	9.00
Maria Gaci	4.20	4	0	18	6.36	1.75	3.25	4.50
Marina Anmls	0.00	0	0	0	0.00	0.00	0.00	0.00

Showing 1 to 10 of 21 entries ‹ 1 2 3 ›

Fig. 4. Group members analytics.

3.4 Development and Performance Issues

InGauge is built in the Ruby language using the Rails framework. Authentication is performed using the OAuth open standard which requests permission from Facebook in order to be able to access a set of data from a user profile. The Facebook Application Programming Interface (API), which enables third party applications to communicate and interface with Facebook features, is used to query the activities of a Facebook group and extract all posts, comments, likes etc. InGauge's interface with the Facebook API is not direct but for simplicity purposes it is implemented using the Koala library [55]. Koala is a Ruby wrapper for the Facebook API, and plays a great role in simplifying the HTTP requests to Facebook. After extracting raw data from Facebook, all calculations are performed on the client-side using Javascript. This decision was taken for performance reasons as Javascript is faster than Ruby [56]. Having in mind the high level of complexity of the calculations, we performed a number of tests and we determined that Javascript allowed for considerable difference in performance. The two main Javascript front-end libraries that we utilise are JQuery and Twitter Flight. Regarding storage requirements, the MySQL database is used to store the preferences and settings that an instructor sets for a specific Facebook group in order to analyse the group's level of engagement. It is worth to note at this point that all calculations for determining the participation score and the engagement level are performed on demand and results are not stored in the database. The reason is that since students can interact with group posts from any point of time, participation is dynamic and can change at any point of time. Finally, user interface components are implemented using Bootstrap, Twitter's front-end open source framework.

4 Discussion

InGauge was designed and developed at the authors' institution and it is currently fully-functional and in closed beta release. Our plan is to have an open beta version ready by December 2015 and make it available to the general public for beta testing purposes in order to determine whether design changes are required. We strongly believe in the potential of InGauge as an educational tool and therefore, we will promote it to high school and higher education instructors who use Facebook groups for academic purposes, as well as, instructors who lead Massive Open Online Courses. The most apparent value of InGauge is that it can easily automate the process of evaluating student engagement in online discussions in the case that participation in the Facebook group is assessed. In general, when participation in a Facebook group needs to be evaluated, the ability to configure a custom assessment model through the Contribution Evaluation Model described in Sect. 3.2 can be proven very valuable for instructors in meeting the requirements of the use of the Facebook group or the needs of the specific groups of students. For instance, a Facebook group within a New Product Development unit that is used to host a brainstorming session for a class project should give more emphasis on new posts as opposed to a group that hosts an idea screening session which should emphasise on comments. Whether participation is assessed or not, InGauge can be proven an extremely valuable academic tool for instructors who use Facebook groups. The measurements that InGauge provides in combination with the offered configurations can help instructors to identify problematic situations not only for participation in the Facebook group but also for the taught material and the course overall. For instance:

- It can provide insights on student engagement for specific topics since instructors can match subject matters with specific periods of time. For example, if a Facebook group is used to supplement face-to-face teaching, a Computer Science instructor may realise that the engagement of the group was much higher for the weeks that recursion was covered compared to the two weeks that dealt with computational complexity.
- It can also easily pinpoint to an instructor at any point of time students who demonstrate low or no participation or students who demonstrate passive behaviour by merely 'liking' posts and comments. An instructor can then approach these students to determine if they require any form of academic attention.

We certainly do not imply that simply by using InGauge, student engagement within a Facebook group will increase. Nor do we imply that Facebook groups are better than traditional online discussion forums. As research studies [57, 58] indicate, simply creating the environment for the discussion, by providing the technology and even a main question to be discussed, is not enough to ensure the success of an online asynchronous discussion. Among a wide number of factors that can influence student participation, instructor intervention [9], peer-pressure [59] and ego motivation [60] have been identified as the most important ones. InGauge can effectively assist instructors in facilitating student online discussions within a Facebook group by providing measurements on participation and engagement.

5 Conclusions and Future Work

This paper introduces InGauge, an innovative web-based application that measures student participation and engagement in an academic Facebook group. Currently, to the best of our knowledge, no similar educational tool exists. Based on established educational theories, the system allows for customization and configuration of a number of parameters that enables instructors to differentiate the quantity and quality of student interactions in the group. It also empowers instructors with the ability to monitor the behaviour of individual students and the whole group over time, thus facilitating identification of possible problematic areas.

While the system is currently in beta release, we are already planning a number of enhancements, such as offering the functionality of comparing engagement levels in different groups and providing graphical representation of interactions between students in the group. However, we are also very keen in determining ways of strengthening student participation. Currently, we are addressing the issue of ego motivation and peer-pressure in order to further motivate students to participate in an academic Facebook group. We have created a gamified approach and we are in the process of integrating virtual achievements (badges) that will be automatically awarded to students and posted in the Facebook group upon reaching specific engagement levels. In addition, we are working on parameterizing InGauge in order to provide access to students and enable them to view their detailed performance in terms of participation and engagement compared anonymously with peers and the group. The above features will further enhance the value of InGauge as an educational tool, addressing student engagement for educational Facebook groups in addition to its engagement analysis capabilities.

References

1. Li, Q.: Knowledge building community: keys for using online forums. TechTrends **48**(4), 24–29 (2000)
2. Thomas, M.J.W.: Learning within incoherent structures: the space of online discussion forums. J. Comput. Assist. Learn. **18**(3), 351–366 (2002)
3. Weaver, R.R., Qi, J.: Classroom organization and participation: College students' perceptions. J. High. Educ. **76**(5), 570–601 (2005)
4. Hurt, N.E., Moss, G.S., Bradley, C.L.: The "Facebook" effect: college students' perceptions of online discussions in the age of social networking. Int. J. Scolarship Teach. Learn. **6**(2), 1–24 (2012)
5. Pempek, T.A., Yermolayeva, Y.A., Calvert, S.L.: College students' social networking experiences on Facebook. J. Appl. Dev. Psychol. **30**(3), 227–238 (2009)
6. DiVall, M.V., Kirwin, J.L.: Using Facebook to facilitate course-related discussion between students and faculty members. Am. J. Pharm. Educ. **76**(2), 32 (2012)

7. Mokoena, S.: Engagement with and participation in online discussion forums. Turk. Online J. Educ. Technol. TOJET **12**(2), 97–105 (2013)
8. Jonassen, D., Davidson, M., Collins, M., Campbell, J., Haag, B.B.: Constructivism and computer-mediated communication in distance education. Am. J. Distance Educ. **9**(2), 7–26 (1995)
9. Andresen, M.A.: Asynchronous discussion forums: success factors, outcomes, assessments, and limitations. Educ. Technol. Soc. **12**(1), 249–257 (2009)
10. Johnson, M., Robson, D.: Clickers, student engagement and performance in an introductory economics course: a cautionary tale. Comput. High. Educ. Econ. Rev. **20**, 4–12 (2008)
11. Bonwell, C.C., Eison, J.A.: Active learning: creating excitement in the classroom. In: 1991 ASHE-ERIC Higher Education Reports ERIC (1991)
12. Howard, J.R., Henney, A.L.: Student participation and instructor gender in the mixed-age college classroom. J. Higher Educ. **69**(4), 384–405 (1998)
13. Webb, E., Jones, A., Barker, P., van Schaik, P.: Using e-learning dialogues in higher education. Innovations Edu. Teach. Int. **41**(1), 92–103 (2004)
14. Biesenbach-Lucas, S.: Asynchronous discussion groups in teacher training classes: perceptions of native and non-native students. J. Asynchronous Learn. Netw. **7**(3), 24–46 (2003)
15. Hammond, M.: A review of recent papers on online discussion in teaching and learning in higher education. J. Asynchronous Learn. Netw. **9**(3), 9–23 (2005)
16. Lamy, M.N., Goodfellow, R.: "Reflective conversation" in the virtual language classroom. J. Lang. Learn. Technol. **2**(2), 43–61 (1999)
17. Garrison, D.R., Anderson, T., Archer, W.: Critical thinking, cognitive presence, and computer conferencing in distance education. Am. J. Distance Educ. **15**(1), 7–23 (2001)
18. Arend, B.: Encouraging critical thinking in online threaded discussions. J. Educators Online **6**(1), 1–23 (2009)
19. Wu, D., Hiltz, S.R.: Predicting learning from asynchronous online discussions. J. Asynchronous Learn. Netw. **8**(2), 139–152 (2004)
20. Grosseck, G., Bran, R., Tiru, L.: Dear teacher, what should I write on my wall? A case study on academic uses of Facebook. Procedia Soc. Behav. Sci. **15**, 1425–1430 (2011)
21. Junco, R.: The relationship between frequency of Facebook use, participation in Facebook activities, and student engagement. Comput. Educ. **58**(1), 162–171 (2012)
22. Facebook Newsroom, August 2015. http://newsroom.fb.com/company-info/
23. LaRue, E.M.: Using Facebook as course management software: a case study. Teach. Learn. Nurs. **7**(1), 17–22 (2012)
24. Jenness, S.E.: Rethinking Facebook: a tool to promote student engagement. J. Aust. N. Z. Student Serv. Assoc. **38**(1), 53–62 (2011)
25. Selwyn, N.: Faceworking: exploring students' education-related use of Facebook. Learn. Media Technol. **34**(2), 157–174 (2009)
26. Pollara, P., Zhu, J.: Social networking and education: using Facebook as an edusocial space. Soc. Inf. Technol. Teach. Educ. Int. Conf. **2011**, 3330–3338 (2011)
27. De Villiers, M.R.: Academic use of a group on Facebook: Initial findings and perceptions. In: Proceedings of Informing Science and IT Education Conference (2010)
28. Kent, M.: Changing the conversation: Facebook as a venue for online class discussion in higher education. J. Online Learn. Teach. **9**(4), 546–565 (2013)
29. Meishar-Tal, H., Kurtz, G., Pieterse, E.: Facebook groups as LMS: a case study. Int. Rev. Res. Open Distance Learn. **13**(4), 33–48 (2012)

30. Petrović, N., Petrović, D., Jeremić, V., Milenković, N., Ćirović, M.: Possible educational use of Facebook in higher environmental education. In: ICICTE 2012 Proceedings, pp. 355–362 (2012)
31. Schroeder, J., Greenbowe, T.J.: The chemistry of Facebook: using social networking to create an online community for the organic chemistry laboratory. Innovate J. Online Educ. **5**(4), 1–7 (2009)
32. Findings, K.: What are students doing with technology? Students Inf. Technol. ECAR Res. Study **6**, 55–72 (2010)
33. Fouser, R.J.: From CMS to SNS: exploring the use of Facebook in the social constructivist paradigm. In: 10th IEEE/IPSJ International Symposium on Applications and the Internet, pp. 221–224 (2010)
34. Ractham, P., Firpo, D.: Using social networking technology to enhance learning in higher education: a case study using Facebook. In: 44th Hawaii International Conference on System Sciences, pp. 1–10 (2011)
35. Poplar, D.: MOOC evolution and one poetry MOOC's hybrid approach, December 2014. http://www.educause.edu/ero/article/mooc-evolution-and-one-poetry-mooc%E2%80%99s-hybrid-approach
36. Jiang, M., Ting, E.: A study of factors influencing students' perceived learning in a web-based course environment. Interface **6**(4), 317–338 (2000)
37. Swan, K., Shen, J., Hiltz, S.R.: Assessment and collaboration in online learning. J. Asynchronous Learn. Netw. **10**, 45–62 (2006)
38. Swan, K.: Virtual interaction: Design factors affecting student satisfaction and perceived learning in asynchronous online courses. Distance Educ. **22**(2), 306–331 (2001)
39. Brace-Govan, J.: A method to track discussion forum activity: the moderators' assessment matrix. Internet High. Educ. **6**(4), 303–325 (2003)
40. Swan, K., Hall, M.: Evaluating online conversation in an asynchronous learning environment: an application of Grice's cooperative principle. J. Internet High. Educ. **10**, 3–14 (2007)
41. Oliver, M., Shaw, G.P.: Asynchronous discussion in support of medical education. J. Asynchronous Learn. Netw. **7**(1), 56–67 (2003)
42. Johnson, D.W., Johnson, R.T.: Computer-assisted cooperative learning. Educ. Technol. **26**(1), 12–18 (1986)
43. Johnson, D.W., Johnson, R.T.: Positive interdependence: key to effective cooperation. In: Hertz-Lazarowitz, R., Miller, N. (eds.) Interaction in Cooperative Groups: The Theoretical Anatomy of Group Learning, pp. 174–199. Cambridge University Press, Cambridge (1995)
44. Grytics – Analytics for Groups, July 2015. http://grytics.com
45. López, M., Luna, J., Romero, C., Ventura, S.: Classification via clustering for predicting final marks based on student participation in forums. In: Proceedings of the 5th International Conference on Educational Data Mining, pp. 148–151 (2012)
46. Davies, J., Graff, M.: Performance in e-learning: online participation and student grades, **36**(4), 657–663 (2005)
47. King, K.P.: Educators revitalize the classroom "bulletin board" a case study of the influence of online dialogue on face-to-face classes from an adult learning perspective. J. Res. Comput. Educ. **33**(4), 337–354 (2001)
48. Dringus, L.P., Ellis, T.: Using data mining as a strategy for assessing asynchronous discussion forums. Comput. Educ. **45**(1), 141–160 (2005)
49. Gellci, J., Hatziapostolou, T.: An algorithm for measuring engagement in Facebook groups. Technical report TR-10, The International Faculty of the University of Sheffield, CITY College (2014)

50. Ferguson, R.: Learning analytics: drivers, developments and challenges. Int. J. Technol. Enhanced Learn. **4**(5/6), 304–317 (2012)
51. Chatti, M.A.: A reference model for learning analytics. Int. J. Technol. Enhanced Learn. **4**(5/6), 318–331 (2012)
52. Dietz-Uhler, B., Hurn, J.E.: Using learning analytics to predict (and improve) student success: a faculty perspective. J. Interact. Online Learn. **12**(1), 17–26 (2013)
53. Mattingly, K.D.: Learning analytics as a tool for closing the assessment loop in higher education. Knowl. Manage. E-Learn. **4**(3), 236 (2012)
54. Picciano, A.G.: Big data and learning analytics in blended learning environments: benefits and concerns. Int. J. Artif. Intell. Interact. Multimedia **2**(7), 35–43 (2014)
55. Koala Gem website - GitHub arsduo/koala, October 2014. https://github.com/arsduo/koala
56. Fabiano P.S.: When to Ruby on Rails, when to Node.js, October 2014. https://fabianosoriani.wordpress.com/2011/09/11/when-to-ruby-on-rails-when-to-node-js/
57. Guldberg, K., Pilkington, R.: A community of practice approach to the development of non-traditional learners through networked learning. J. Comput. Assist. Learn. **22**(3), 159–171 (2006)
58. Mazzolini, M., Maddison, S.: Sage, guide or ghost? The effect of instructor intervention on student participation in online discussion forums. Comput. Educ. **40**(3), 237–253 (2003)
59. Yang, X., Li, Y., Tan, C.-H., Teo, H.-H.: Students' participation intention in an online discussion forum: Why is computer-mediated interaction attractive? Inf. Manage. **44**(5), 456–466 (2007)
60. Dillon, C., Greene, B.: Learner differences in distance learning: finding differences that matter. In: Moore, M.G., Anderson, W.G. (eds.) Handbook of Distance Education, 239, p. Routledge, London (2003)

Can Playing Massive Multiplayer Online Role Playing Games (MMORPGs) Improve Older Adults' Socio-Psychological Wellbeing?

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Abstract. This study examined whether playing Massive Multiplayer Online Role-Playing Games (MMORPGs) improves older adults' socio-psychological wellbeing. We analyzed the relationships of older adults' social interactions in MMORPGs to three socio-psychological factors: loneliness, depression, and social support. Social interactions in MMORPGs were conceptualized into four components: communication methods, network level, enjoyment of relationships and quality of guild play. A total of 222 respondents aged 55 years or more who played World of Warcraft (WoW) were recruited through an online survey. It was found that the biggest effect sizes of loneliness, depression, and social support were associated with enjoyment of relationships and quality of guild play. In addition, amount of gameplay had a little impact on older adults' socio-psychological wellbeing. Therefore, the socio-psychological impacts of playing MMORPGs on older adults are much dependent on the enjoyment of relationships and quality of guild play.

Keywords: MMORPGs · World of Warcraft · Social interaction · Older adults · Wellbeing

1 Introduction

1.1 Social Interaction and Successful Aging

Successful aging - maintaining an independent, positive, healthy, and meaningful quality of life – is a continual challenge for older adults. It is, however, essential for them and for their societies, which benefit both from their continuing contributions and from reduced social and care costs [1]. Gerontology researchers have demonstrated that cognitive and social factors are key elements for enhancing older adults' quality of life. The buffering hypothesis [2] indicates that the existence of one's social network, as well as substantive interactions generated among social ties, can buffer people from negative events. People who have close friends and confidants, friendly neighbours, and supportive co-workers are less likely to experience sadness, loneliness, low self-esteem, and problems with eating and sleeping, whereas people who are socially disconnected are between two and five times more likely to die from all causes [3]. Older adults who maintain close friendships and find other ways to interact socially have a reduced risk of mental health issues and live longer than those who become isolated [4].

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Empirical studies have demonstrated positive relationships between social interaction and successful aging, although the mechanisms underlying this are not clear [5]. For example, Eisenberger et al.'s study [6] found that after 10 days of regular social interaction, individuals showed diminished neuroendocrine stress responses and lower social separation distress. Golden et al. [7] found that social engagement was associated with lower depression and anxiety disorder; lower wellbeing, depressed mood, and hopelessness were all independently related to non-integrated social networks.

1.2 Social Interactions in MMORPGs

Massive Multiplayer Online Role-Playing Games (MMORPGs) are extensive and persistent 3D environments in which hundreds of thousands of players can play together no matter where they are physically located [8]. To enter a game world, players first create characters from a set of classes and races as digital representations of themselves. Each character has a specific set of skills and abilities that define that character's role. For example, in World of Warcraft (WoW, a popular MMORPG) "mages" are powerful spell casters who use magic to inflict damage on their enemies from afar but are very vulnerable to attacks. These traits define the role of the mage: hang back, do a ton of damage, and hope to kill the monsters before they reach the player. Characters are purposefully designed to be interdependent. Over the course of a character's life, the character will brave thousands of quests, some of which are too difficult to be overcome by a single player. Players need to form a well-balanced group in order to combat the quest and progress quickly through the games. This framework shapes player-to-player interactions. As Ducheneaut et al. [8] pointed out, "it is structured so that players must interact" (p. 133).

Playing MMORPGs is not only about mindlessly killing monsters, but also about learning and participating in the shared practices of a game community [9]. A MMORPG community is as dynamic and complex as the real world. A typical group requires players to fulfill a number of roles, which are summarized as kill, irritate, and preserve [10]. A good group needs an appropriate balance of all three roles, as well as successful team cooperation and coordination, in order to stand a realistic chance of success. Maintaining group cohesion and encouraging positive communication are important for a group's collective wellbeing.

Players form contacts and develop relationships of trust and accountability based on their characters' attributes, actions, and network of affiliations [11]. Social interaction is a primary driving force for players to continue to play MMORPGs, contributing considerably to the enjoyment of playing [12]. The functional constructs of MMORPGs facilitate some social groups, known as guilds. A guild is an organized group of players that regularly play together and is formed to make collective actions easier and more rewarding, as well as to create a social atmosphere. Each guild has its own rules, and membership in a guild is monitored and regulated. Building positive social skills (e.g. behaving in a friendly and helpful way to other players) is therefore a necessity if a player wishes to either participate in communities or successfully complete the harder challenges of the game [10]. When a new group is formed, a chat channel is automatically created that only group members can use. This allows players to request help, strategize on group quests, and socialize. They can also interact with others through person-to-person instant messaging, Voice over Internet Protocol (VoIP - an Internet-based auditory chatting system), and site forums.

Schiano et al. [13] found that the majority of WoW players played the game with others rather than alone. Cole and Griffiths [14] found that 26.3 % of participants played MMORPGs with family and real-life friends. Whippey [15] reported that 82 % of participants who were involved in guild life often had conversations with their guild mates, and 66 % often spent time playing with their guild. Williams et al.'s study [16] found that 60 % of guild members used VoIP systems, and roughly 60 % of interviewees belonged to a social guild in which the primary goal was social interaction. Yee [17] reported that 39.4 % of male players and 53.3 % of female players felt that their MMORPG friends were comparable to or better than their real-life friends. In Whippey's study [15], 54 % of participants felt that their game friends were comparable to their real-life friends. All of these studies provide evidence that playing MMORPGs provides opportunities to sustain off-line relationships and to develop meaningful and supportive new relationships.

Some studies have focused on testing the socio-psychological impacts of playing MMORPGs among younger players. Visser et al. [18], examining the effects of playing WoW on adolescents' loneliness, found that there was no difference in the level of loneliness between WoW players and non-WoW players and no significant effect on loneliness from time spent playing WoW. However, Kirby et al. [19], using a cross-sectional questionnaire to explore the association between average hours playing WoW per week and psychological wellbeing, found a negative correlation between playing time and psychological wellbeing. These two studies correlated self-reported measures of playing time with measures of psychological wellbeing but reported conflicting results.

Dupuis and Ramsey [20] tested a mediated model examining whether higher social involvement in MMORPGs was associated with lower levels of depression via engendering a perception of social support. Game involvement was measured by a 13-item scale developed by the researchers, with items such as "If I had a personal problem that was really bothering me, I would rather tell my online friends than friends I have in real life" and "I have more good friends online than I do in real life." The study found that involvement in MMORPGs was not related to perceived social support, but a lack of perceived social support was associated with higher levels of depression. Trepte et al. [21] found that online game players' physical and social proximity, as well as their mutual familiarity, influenced bridging and bonding social capital, and the two types of social capital were positively associated with offline social support. Domahidi et al. [22] found that there was a significant impact of social online gaming frequency (measured by general gaming frequency and the average duration of a typical social online gaming session) on the probability of meeting exclusively online friends; players with a strong motive to gain social capital and to play in a team had the highest probability of transforming their social relations from online to an offline context. These studies went beyond the simple measure of playing time and conceptualized social interactions in MMORPGs differently.

1.3 Description of World of Warcraft

This research investigated older adults' social interaction in the MMORPG World of Warcraft (WoW). At the time of this study, WoW was the most played game in North America, and the most highly subscribed MMORPG worldwide, with a total of over 10 million customers [23]. After character creation and customization, players can begin questing in Azeroth, a medieval fantasy 3D environment. Characters start at level one and progress to higher levels by gaining experience points. Essentially, the core gameplay of WoW revolves around fighting monsters and completing quests. Every quest is unique and involves a new level of challenge. Group quests are more challenging than normal quests but offer better rewards; they can only be conquered by groups of players working together as a team. For raid quests, players must face challenges in the game's most perilous places. These quests require a large group (10 or 25 players) to complete but allow players to earn the game's greatest treasures. If players defeat the most powerful beings in WoW, they can wear these treasures proudly to let others know that they have proved their worth.

At its core, what makes WoW such a fun game is the "shared experience, the collaborative nature of most activities and, most importantly, the reward of being socialized into a community of gamers and acquiring a reputation within it" [8, p. 131]. Interactive groups in WoW are of two types: groups and guilds.

Groups are limited to five players, but players can also form a raid group, which can include up to 40 people. Groups are temporary and cease to exist once all members leave or log off.

Guilds are more permanent and much larger groups of players united to help each other and play the game together. To show support for their guild and differentiate themselves from others, guilds allow their members to wear a tabard (a shirt with a color and icon selected by the guild officers) and to publicly display the guild name underneath their name. As guild members grow in number and play together, their guild earns experience points that eventually translate into special perks and bonuses for their guild as a whole. The more guild members play with each other, the more experience points they earn for their guild.

WoW includes a sophisticated chat system that allows players to talk among themselves. They can set up private channels to talk to friends only, or they can chat in the local/global chat channels to reach a larger audience. Those in a guild have access to their guild's own chat channel. Instead of typing words to chat with others, players can also use WoW's built-in VoIP chat system, commonly used by guilds.

2 Research Question

As discussed above, it is well established that social interaction is an important component of successful aging (e.g., see [24]). Sociologist Georg Simmel (1949) defined sociability as "the art or play form of association…" [25, p. 254]. He described sociability as a basic human "impulse," "the sheer pleasure of the company of others," and "the central ingredient in many social forms of recreation and play." MMORPGs are a wholly new form of community and social interaction, and playing MMORPGs links people from all over the world as they engage in a shared virtual world and collective play experience. MMORPG gameplay can maintain real-life relationships and facilitate new ones, providing more opportunities to obtain social resources. MMORPGs are good places for sociability [26].

Exploring this phenomenon in the context of aging, the current study was guided by the research question: *Are there associations between the social interactions in MMORPGs and various socio-psychological benefits for older adults?*

3 Definition of Variables

Before drawing any conclusions about the impacts of MMORPGs, the underlying variables involved in older adults' social interactions in MMORPGs should be determined [16]. As described above, previous studies used the amount of gameplay as a gross measure of social interactions in MMORPGs. Frequent participation in gameplay increases the chance of social interaction, but this doesn't fully describe social interactions in MMORPGs. Shen and Williams [27] found that the association of social interactions with negative or positive outcomes was very much dependent on the purposes, contexts, and individual characteristics of users. Considering only the amount of gameplay may oversimplify older adults' social interactions in MMORPGs.

At present, there are few shared theories or common practices for describing human social experiences in virtual worlds. To support research progress in this area, Williams [28] developed a research framework to map behaviours in these environments. Inspired by Williams's study, this research conceptualized older adults' social interactions in MMORPGs as follows:

- **Communication Methods.** Communication is the most important aspect of players' interactions in MMORPGs [27]. Nardi and Harris [29] found that chatting is a key aspect of socializing in WoW, taking place not only when grouping and fighting, but also when players are soloing (adventuring alone) or traveling in the game.
- **Network Level.** This refers to the position of players in their social network. It is another key variable when understanding the outcomes of MMORPG playing [28]. Shen et al. [30] indicated that the measure of network level is essentially the same as centrality. Individuals who are in a central position within a network are usually more accessible than others [31].
- **Enjoyment of Relationships.** This affects how much social support players can exchange while playing together. Gameplay involves not only joint in-game activities but also, and overwhelmingly, constant conversation about the game and topics well beyond it, ranging from debates about the mechanics of the game to intimate personal problems. Some players trust their game friends and see them as important as real-life friends, while others see their game friends as not particularly important to them [16].
- **Quality of Guild Play.** In MMORPGs, the guild is a place where deep relationship occurs [32]. Players in formally structured guilds tend to have more social experiences than others [16]. This positively affects the quality of their time in the game. So, quality of guild play determines whether its impact on social interactions is positive or negative.

4 Methods

4.1 Procedure

Data were collected through an online questionnaire, described below. Prior to recruiting participants, ethics approval was obtained from the Department of Research Ethics at the university where the study was conducted. To recruit participants, invitation messages providing the questionnaire URL were posted on eight WoW player forums. By beginning the survey, respondents indicated that they had read and understood the study purposes, thus satisfying ethics protocol.

4.2 Participants

Smith [33] reported that the adoption of technology decreases with advanced age and drops off notably starting at around age 75. Gell et al. [34] found that technology use among older adults was associated with younger age, decreasing significantly with greater limitations in physical function and greater disability. People at the age of 55 are still active and participative. As they go into their seventies or eighties, they are more likely to suffer from some physical and cognitive decline, and even impairment, which might negatively affect their use of MMORPGs. We expected that people in their late fifties would use more information technology than older respondents; therefore, we set 55 as the age cutoff for the study. Participants were English-speaking WoW players aged 55 and over. A total of 222 eligible respondents completed their surveys and were the participants of this study.

4.3 Survey Design

The final survey consisted of three sections. The first section focussed on respondents' playing patterns: amount of gameplay, level of main character, and social motivation for playing MMORPGs. The second section asked about their social interactions within WoW. This section included four measures:

- **Communication Methods** were measured by asking how frequently older adults communicated with others via public chat, group chat, private chat, in game voice chat, social media, and face-to-face meetings. Participants were asked to indicate on a 5-point scale (1 = Never, 5 = All the time) the frequency of using these communication tools.
- **Network Level** was measured by asking how frequently older adults played with family, real-life friends, game friends, and other players. Respondents were asked to indicate on a 5-point scale (1 = Never, 5 = All the time) the frequency of playing with these persons.
- **Enjoyment of Relationships** was measured by the strength of relationships with family, real-life friends, and game friends. Respondents were asked to indicate on a 5-point scale (1 = Strongly disagree, 5 = Strongly agree) to what extent they agreed with these statements: (a) Playing with family members makes me feel closer to

them; (b) Playing with real-life friends makes me feel closer to them; (c) I trust my game friends; (d) My game friends are as important to me as my real-life friends. They were also asked to indicate on a 5-point scale (1 = Never, 5 = All the time) how often they engage in: (a) Talk about WoW with my family; (b) Talk about WoW with my real-life friends; (c) Share my personal problems with game friends. High ratings on these statements were identified by Steinkuehler and Williams [32] and Williams et al. [16] as indicating deep relationships.
- **Quality of Guild Play** was measured by time of guild play and satisfaction with guild play. Satisfaction with guild play was measured by asking respondents to indicate how satisfied they were with the organization of the guild, guild leadership and guild members, with "1" = "Very dissatisfied" and "5" = "Very satisfied."

The third section of the questionnaire consisted of socio-psychological measures of loneliness, depression and social support. These factors reflect different social conditions, but are highly related as interpersonal relationship is an important part of them. Specifically:

- **Loneliness** was assessed using the short-form of the UCLA Loneliness scale (ULS-8) [35]. The scale is an instrument indexing the frequency of an individual's feelings of loneliness and lack of companionship. Participants rated each item on a scale from 1 (Strongly disagree) to 5 (Strongly agree), with higher scores indicating lower levels of loneliness. The reliability is .88.
- **Depression** was measured by the 10-item Center for Epidemiological Studies Depression scale (CES-D) [36]. CES-D is designed to assess one's current level of depression and is one of the most commonly used measures in a normal, as opposed to pathological, population. It is rated on a 5-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree), with higher scores indicating lower levels of depression. Its reliability is .86.
- **Social Support** was measured using the Multidimensional Scale of Perceived Social Support (MSPSS) [37]. The MSPSS measures how one perceives their social support system, including sources such as family, friends, and significant other. Items are rated on a 5-point Likert-scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Higher scores indicate higher levels of perceived social support. The reliability of this scale is .93.

4.4 Data Analysis

As discussed above, the amount of gameplay is an important factor (but not the only one) that affects a player's level of psychological wellbeing; previous studies have reported conflicting results in terms of its effects. To address this problem and examine the associations of older adults' social interactions in MMORPGs with socio-psychological benefits, a series of two-stage hierarchical regression analyses were performed. The amount of game play was used as a covariate, each of the socio-psychological measures as an outcome variable, and the factors in each component of social interaction as independent variables. To compare the effect size of each component of social interaction on each outcome measure (e.g., which one of the four components of social interactions in MMORPGs generated the biggest effect size on loneliness), Cohen's f2 of each individual hierarchical regression analyses was computed. By convention, effect sizes of .02, .15 and .35 were termed small, medium, and large, respectively [38]. Data analysis was carried out using IBM Statistics SPSS 22.0. All regression analyses were carried out with an alpha level of .01.

5 Results

5.1 Respondent Backgrounds

A total of 222 people completed the survey, of which 176 provided their demographic information. Approximately 33 % were female, and 67 % were male. Yee [17] found that MMORPG players are roughly 85 % male. Thus, compared with young adults, there were more female older MMORPG players in our sample.

A significant majority of respondents (62.7 %) were aged between 55 and 59, while only 20.9 % were between 60 and 64, and 1.2 % aged 70–79. The large proportion of older gamers who were in the age group of 55–59 justified the use of "55" as the lower age cut point. Notably, only 6.2 % of participants were aged 80 years of age or older.

In terms of relationship status, 61 % of participants were married, and 20.8 % were separated or divorced. One fourth of participants (25.4 %) lived alone, while others lived with spouse or common law partner (42.1 %), family (26.2 %), or someone else (6.3 %).

More than half of the participants (53.1 %) were employed full-time, and 9.5 % were part-time employed. For the highest level of education, 39.1 % of participants had completed a four-year degree, 20.1 % had completed a master's degree, and 7.8 % had achieved a doctoral degree.

Regarding gameplay patterns, 40 % of participants played WoW seven days per week on average, 12.2 % played 6 days per week, and an identical 12.2 % played 5 days per week. Fully 41 % of participants spent 2 or 3 h per day on average playing WoW, 28.4 % played 4 to 5 h per day, and approximately 22 % played more than 6 h per day. Taken together, 65 % of participants played WoW at least 5 days per week, and on average 92 % spent at least 3 or 4 h per day playing WoW, which equals the working hours of a part-time job.

A substantial majority of participants had already achieved a high level in the game. The highest level of approximate 84.2 % of participants' main character (the one participants played most often if they played several characters) was 80 and higher. (In 2014, the maximum level in the game was 90).

To summarize, the majority of older WoW players in this study were "young" older adults in their late 50 s or early 60 s. A substantial majority of them still maintained a normal amount of face-to-face social contact and were well-educated. In addition, the majority could be defined as heavy gamers, based on De Schutter's [39] criteria, as they play digital games more than 2.5 h per day.

5.2 Playing Time

No significant differences in the total amount of gameplay were found with respect to relationship status (*F* (3, 174) = .723, *p* = .539), living situation (*F* (3, 122) = 1.014, *p* = .389), or work situation (*F* (3, 175) = 1.138, *p* = .335).

5.3 Associations Among Variables

Because of the small percentage of participants in age groups 65–69, 70–74, 75–79, and 80+, these were combined as 65+. A one-way analysis of variance (ANOVA) showed that the three age groups (i.e., 55–59, 59–64, and 65+) differed significantly from each other in the time they spent playing WoW (*F* (2, 174) = 5.600, *p* = .004). A Bonferroni post hoc test indicated that the age group 65+ (*M* = 3.31, *SD* = 1.198) played significantly more than the age group 55–59 (*M* = 2.59, *SD* = 1.030, *p* = .004) and the age group 59–64 (*M* = 2.62, *SD* = .953, *p* = .026).

The ANOVA analysis indicated that playing time also differed significantly with participants' education level (*F* (5, 173) = 2.583, *p* = .028). A Bonferroni post hoc test revealed that the less-than-high school group (*M* = 3.78, *SD* = 1.563) spent significantly more time playing games than did the high school group (*M* = 2.61, *SD* = .933, *p* = .050), 4-year degree group (*M* = 2.60, *SD* = .954, *p* = .026), or master`s degree group (*M* = 2.61, *SD* = 1.050, *p* = .048).

5.4 Gender Differences

Females (*M* = 2.67, *SD* = 1.526) were more likely to play with family (*t* (175) = 2.296, *p* = .023) in comparison to males (*M* = 2.17, *SD* = 1.291). They were also more likely to share personal problems (*t* (175) = 2.420, *p* = .017), to discuss gameplay with game friends (*t* (175) = 2.417, *p* = .017), and to talk about WoW with family (*t* (162) = 2.202, *p* = .029). However, there was no significant gender difference in terms of enjoyment of relationships and amount of guild play. Females enjoyed relationships in WoW as much as males did and spent the same amount of time in guilds as did males.

5.5 Predictors of Outcome Variables

Table 1 presents the analysis results for communication methods during gameplay. The amount of gameplay was a significant covariate only for depression. When the six variables of communication methods were added to the block, only the second prediction model of depression was statistically significant. However, the R2 change of depression was not statistically significant, F_c (6, 201) = 2.040, p_c = .062, R_c^2 = .056. This indicates that the frequency of using different methods to communicate with other players was not related to the feelings of loneliness, depression and social support.

As seen in Table 2, the amount of gameplay was a significant covariate for depression. When the four variables of network level were added to the block, all of the second prediction modes were statistically significant, but only the R^2 changes of loneliness and social support were statistically different from zero. The four variables of

Table 1. Results of communication methods.

Outcome measure	Model 1			Model 2			Change		
	F	*p*	R^2	*F*	*p*	R^2	F_c	p_c	R_c^2
Loneliness	4.876	.028	.024	1.287	.259	.044	.696	.653	.021
Depression	7.081	.008	.033	2.791	.009	.089	2.040	.062	.056
Social support	2.949	.088	.015	1.687	.114	.059	1.470	.191	.044

network level accounted for 6.8 % of the variance of loneliness (F_c (4, 196) = 3.664, p_c = .007, R_c^2 = .068) and 8.5 % of the variance of social support (F_c (4, 189) = 4.451, p_c = .002, R_c^2 = .085). Both loneliness and social support were mostly predicted by playing with family, as shown in Tables 3 and 4.

Table 2. Results of network level.

Outcome measure	Model 1			Model 2			Change		
	F	*p*	R^2	*F*	*p*	R^2	F_c	p_c	R_c^2
Loneliness	4.876	.028	.024	3.958	.002	.092	3.664	.007	.068
Depression	7.081	.008	.033	3.646	.004	.082	2.729	.030	.049
Social support	2.949	.088	.015	4.192	.001	.100	4.451	.002	.085

Table 3. Hierarchical regression results for loneliness (*N* = 202).

Block	R^2	Model	*b*	*SE-b*	Beta	*r*	sr^2	*sc*
1	.024	Constant	3.765	.144				
		Amount of play	−.079	.036	−.154	−.154	.024	−1
2	.092	Constant	3.351	.258				
		Amount of play	−.072	.035	−.142	−154	.020	−.508
		Family*	.164	.047	.248	.261	.057	.861
		Real-life friends	.013	.053	.017	.083	<.001	.274
		Game friends	.037	.057	.052	.046	.002	.152
		Other players	−.045	.063	−.057	−.024	.002	−.079

Note. sr^2 = squared semi-partial correlation; *sc* = structure coefficient; $*p < .01$.

Analysis of the component of enjoyment of relationships (Table 5) showed that the amount of gameplay was not a significant covariate for any of the three socio-psychological measures. When the seven variables of enjoyment of relationships were added to the block, the second prediction modes of loneliness and social support were statistically significant, and their R^2 changes were also statistically different from zero. For loneliness (Table 6), the seven variables accounted for 9.8 % of its variance, F_c (7, 177) = 2.786, p_c = .009, R_c^2 = .098. However, none of the predictors in the model

Table 4. Hierarchical regression results for social support (N = 195).

Block	R^2	Model	b	$SE\text{-}b$	Beta	r	sr^2	sc
1	.015	Constant	3.825	.159				
		Amount of play	−.068	.040	−.123	−.123	.015	−1
2	.100	Constant	3.064	.278				
		Amount of play	−.071	.039	−.128	−.123	.016	.389
		Family*	.154	.051	.217	.258	.043	.816
		Real-life friends	.080	.058	.103	.181	.009	.573
		Game friends	.064	.063	.084	.116	.005	.367
		Other players	−.001	.069	−.002	.052	<.001	.165

Note. sr^2 = squared semi-partial correlation; sc = structure coefficient; *p < .01.

was statistically significant. This means that none of the predictors was able to account for a statistically significant portion of the variance of loneliness when other predictors acted as covariates. The seven variables explained 20.1 % of the variance of social support, F_c (7, 173) = 6.419, $p_c < .001$, $R_c^2 = .201$. It was mostly predicted by feeling close to real-life friends (see Table 7).

Table 5. Results of enjoyment of relationships.

Outcome measure	Model 1			Model 2			Change		
	F	p	R^2	F	p	R^2	F_c	p_c	R_c^2
Loneliness	2.504	.115	.013	2.772	.007	.111	2.786	.009	.098
Depression	4.447	.036	.023	2.017	.047	.082	1.655	.123	.059
Social support	4.949	.027	.027	6.336	<.001	.227	6.419	<.001	.201

Table 6. Hierarchical regression results for loneliness (N = 186).

Block	R^2	Model	b	$SE\text{-}b$	Beta	r	sr^2	sc
1	.013	Constant	3.697	.155				
		Amount of play	−.061	.038	−.116	−.116	.013	−1
2	.111	Constant	3.109	.330				
		Amount of play	−.031	.040	−.059	−.116	.003	−.347
		Talk WoW with family	.136	.069	.182	.150	.020	.449
		Talk WoW with RLF	−.023	.072	−.029	.045	<.001	.135
		Close to family	.081	.074	.102	.210	.006	.629
		Close to RLF	.064	.080	.073	.116	.003	.347
		Share personal story with GF	−.115	.069	−.146	−.125	.014	−.374
		Trust GF	.130	.098	.139	.023	.009	.069
		GFs as important as RLF	−.159	.072	−.208	−.130	.024	−.389

r^2 = squared semi-partial correlation; sc = structure coefficient; GF = Game Friends; RLF = Real-Life Friends; *p < .01.

Table 7. Hierarchical regression results for social support (N = 182).

Block	R^2	Model	*b*	*SE-b*	Beta	*r*	sr^2	*sc*
1	.027	Constant	3.929	.164				
		Amount of play	−.091	.041	−.164	−.164	.027	−1
2	.227	Constant	2.212	.328				
		Amount of play	−.085	.039	−.153	−.164	.021	−.344
		Talk WoW with family	.110	.069	.139	.200	.011	.419
		Talk WoW with RLF	<.001	.071	<.001	.189	<.001	.396
		Close to family	.069	.075	.082	.321	.004	.673
		Close to RLF*	.256	.082	.274	.383	.044	.803
		Share personal story with GF	.048	.069	.057	.119	.002	.249
		Trust GF	.184	.100	.181	.240	.015	.503
		GFs as important as RLF	−.151	.074	−.186	.036	.019	.075

Note. sr^2 = squared semi-partial correlation; *sc* = structure coefficient; GF = Game Friends; RLF = Real-Life Friends; *p < .01.

Table 8 shows the results for quality of guild play. The amount of gameplay was not a significant covariate for any of the three socio-psychological measures. When the four variables of quality of guild play were entered into the model, all of the second prediction modes were statistically significant. The R^2 changes of loneliness, depression, and social support were statistically different from zero. For loneliness (Table 9), the four variables of quality of guild play explained 13.2 % of its variance, F_c (4, 172) = 6.673, p_c < .001, R_c^2 = .132. It was mostly predicted by satisfaction with guild mates. Fully 14 % of the variance of depression (Table 10) was explained by quality of guild play, F_c (4, 179) = 7.483, p_c < .001, R_c^2 = .140. Similar to loneliness, it was mostly predicted by satisfaction with guild mates. For social support (Table 11), approximately 15 % of its variance was explained by the quality of guild play, F_c (4, 166) = 7.569, p_c < .001, R_c^2 = .152, and it was mostly predicted by satisfaction with guild leadership.

Table 8. Results of quality of guild play.

Outcome measure	Model 1			Model 2			Change		
	F	*p*	R^2	*F*	*p*	R^2	F_c	p_c	R_c^2
Loneliness	2.977	.086	.017	6.010	<.001	.149	6.673	<.001	.132
Depression	3.689	.056	.020	6.829	<.001	.160	7.483	<.001	.140
Social support	2.670	.104	.015	6.672	<.001	.167	7.569	<.001	.152

Table 12 presents Cohen's effect size (f^2) for all outcome measures. The biggest effect sizes for loneliness (f^2 = .152) and depression (f^2 = .167) were associated with quality of guild play. Their magnitude was medium based on Cohen's criteria [38]. The biggest effect size of social support (f^2 = .259) was associated with enjoyment of relationships, and its magnitude was medium to large. Communication methods and

Table 9. Hierarchical regression results for loneliness (*N* = 178).

Block	R^2	Model	*b*	*SE-b*	Beta	*r*	sr^2	*sc*
1	.017	Constant	3.741	.156				
		Amount of play	−.066	.039	−.129	−.129	.017	−1
2	.149	Constant	2.357	.350				
		Amount of play	−.040	.044	−.077	−.129	.004	−.334
		Amount of guild play	−.067	.038	−.153	−.112	.016	−.290
		Organization of guild	−.001	.100	−.001	.222	<.001	.575
		Leadership	.087	.077	.095	.213	.006	.552
		Guild members*	.313	.093	.318	.320	.056	.829

Note. sr^2 = squared semi-partial correlation; *sc* = structure coefficient.

Table 10. Hierarchical regression results for depression (*N* = 185).

Block	R^2	Model	b	SE-b	Beta	r	sr^2	sc
1	.020	Constant	3.824	.140				
		Amount of play	−.067	.035	−.141	−.141	.020	−1
2	.160	Constant	2.416	.299				
		Amount of play	−.074	.039	−.156	−.141	.017	−.353
		Amount of guild play	−.012	.034	−.029	−.035	.001	−.088
		Organization of guild	.063	.090	.070	.289	.002	.723
		Leadership	.076	.069	.093	.255	.006	.638
		Guild members*	.239	.084	.270	.345	.038	.863

Note. sr^2 = squared semi-partial correlation; sc = structure coefficient.

Table 11. Hierarchical regression results for social support (*N* = 172).

Block	R^2	Model	*b*	*SE-b*	Beta	*r*	sr^2	*sc*
1	.015	Constant	3.854	.165				
		Amount of play	−.067	.041	−.124	−.124	.015	−1
2	.167	Constant	2.173	.366				
		Amount of play	−.058	.046	−.109	−.124	.008	−.303
		Amount of guild play	−.046	.039	−.102	−.063	.007	−.154
		Organization of guild	−.004	.106	−.003	.241	<.001	.589
		Leadership*	.225	.084	.238	.339	.036	.829
		Guild members	.239	.106	.224	.303	.026	.741

Note. sr^2 = squared semi-partial correlation; *sc* = structure coefficient.

network level generated smaller effects sizes for loneliness, depression and social support compared with the effects sizes generated by enjoyment of relationships and quality of guild play. The magnitudes of the effect sizes generated by communication methods and network level were small.

Table 12. Cohen's effect size (f^2) of outcome measures.

Measure*	Communication methods	Network level	Enjoyment of relationships	Quality of guild play
Loneliness	.021	.075	.110	.155
Depression	.061	.053	.064	.167
Social support	.047	.094	.259	.182

6 Discussion

Instead of using the gross measure of playing time to quantify MMORPG use, this research categorized social interactions into four components: communication methods, network level, enjoyment of relationships, and quality of guild play, and analyzed how these were associated with loneliness, depression and social support. With the amount of gameplay as a covariate, results indicate that network level and enjoyment of relationships were negatively associated with loneliness and positively associated with social support; higher levels of quality of guild play were related to higher levels of social support and lower levels of loneliness and depression. However, higher frequency of using various methods to communicate with others was not related to any of the three socio-psychological measures.

The largest effect sizes for loneliness and depression were associated with quality of guild play. Loneliness was mostly predicted by satisfaction with guild mates, and social support was predicted by satisfaction with guild leadership. This could be the result of membership in guilds, since built-in game mechanisms require guild members to coordinate with each other in order to achieve tasks, have a higher chance of winning, and get rewards and reputation. As a result of this collective identity, trust and friendship is more likely to develop among guild members through repeated collaboration in groups and raids [26]. Shen's study found that guild membership was positively related to players' level of sociability. Guild players were more likely than non-guild players to participate in social activities such as chat, trade, and collective quests. High quality of guild play indicates that guild members enjoy playful experiences in the guilds, have similar values and play styles, and have well-developed networks of communication and cooperation.

Loneliness refers to the subjective feeling state of being alone, separated, or apart from others [40]. Ernst and Cacioppo [41] conceptualized it as an unfavorable balance between actual and desired social contact. Heylen's study [42] found that more frequent social activities and satisfaction with these activities are linked to lower risk of loneliness. Depression is defined as "a temporary mental state or chronic mental disorder characterized by feelings of sadness, loneliness, despair, low self-esteem, and self-reproach" [43]. Loneliness and depression are both related to benefits, support, and resources found in interpersonal contact in social networks, together with satisfaction in the contact. Participation in guild activities provides older adults with many opportunities for informal sociability and could be an important source of interpersonal relationships and social support.

The largest effect size for social support was associated with enjoyment of relationships, and the magnitude of the effect size was medium to large. Quality of guild play also generated medium to large effect size on social support. At the individual level, social support refers to "the companionship and the practical, informational and esteem support which derive from a person's social network" [44, p. 18]. It reflects the reality or perception that one is part of a social network and is the natural counterpart to social isolation and loneliness [40]. Discussing WoW with family and real-life friends, sharing personal stories with game friends, and cooperation with guild members could facilitate "practical, informational and esteem support." A guild is a place where deep relationships occur [32]. Being a guild member and gaining a reputation from it can build players' self-esteem. These findings are consistent with socio-emotional selectivity theory, which indicates that older adults prefer emotionally gratifying social contacts and emphasize emotionally meaningful aspects of relationships.

Communication methods and network level generated smaller effects sizes for loneliness, depression, and social support compared with the effect sizes generated by enjoyment of relationships and quality of guild play. This finding is predictable and reasonable. Communication methods and network level provide older adults many opportunities to interact with other players and expose them to different viewpoints, but they don't indicate the intention or content of these activities. Communicating and collaborating with other players (regardless of which tool is used or with whom) does not automatically create a deep social bond.

The amount of gameplay was not associated with older adults' feelings of loneliness, depression, or social support when other variables related to social interactions in the game were taken into account. In addition, the amount of gameplay was not a significant covariate for enjoyment of relationships and quality of guild play. On the one hand, these findings are compatible with Shen's finding [26] that time spent had a very small overall impact on players' psychosocial wellbeing. On the other hand, considering only the socio-psychological effects of gameplay time, while ignoring the quality and content of social interactions, conceals the nature and meanings of older adults' social interactions in MMORPGs. Time spent in the game will engender deep interpersonal relationships if playing is not only about mindlessly killing monsters but also about engagement in meaningful social activities. As researchers, we should go beyond simply analyzing the relationships between gameplay time and psychosocial wellbeing, changing the question to "how time spent in the game affects players' psychosocial wellbeing."

We are aware of some limitations of this research. The first is associated with survey research. Because all data collected for this study relied on self-reports, issues of social desirability and accuracy of responses need to be taken into account. The second limitation is related to the Web survey. Because the majority of participants were heavy gamers and had reached high levels in the game, our sample may have been biased toward expert players. Finally, the sample comprised volunteers who were willing to complete the survey.

Zhang and Kaufman [45] examined the impacts of social interactions in MMORPGs on social capital for older adults. Social motivation for playing MMORPGs was positively related to bridging and bonding social capital. Therefore, future research could examine whether social motivation is also related to older adults' socio-psychological wellbeing. In addition, the reasons why older adults play MMORPGs are still not clear. Further qualitative research is clearly needed to understand the causes, contexts, and circumstances of older adults' gameplay. For example, is it for socializing, to keep the mind sharp and reflexes quick, or for other reasons? Also, it is important to clarify the process by which social contacts and social support result from gameplay. What's more, the findings can form a solid foundation for conducting future randomized controlled trials to measure and evaluate the impacts of MMORPG playing on older adults.

7 Conclusion

This study analyzed the relationships between older adults' social interactions in MMORPGs (specifically, WoW) and three socio-psychological factors. Regression analyses revealed that enjoyment of relationships and quality of guild play has deep impacts on older adults' socio-psychological wellbeing. This study contributes to the knowledge of older adults' social experiences in MMORPGs and how they influence their social and psychological lives. The findings can inform the design and development of digital games and community activities aimed at helping older gamers benefit from this technology.

As part of the life cycle, age-related declines in social contacts and physical and cognitive functions are common, sometimes leading to social and psychological problems such as loneliness, depression, and lack of social support. The results of this research are encouraging in that they provide empirical evidence that playing MMORPGs is an effective way to increase older adults' social contacts and facilitate meaningful relationships. Understanding the opportunities and challenges presented by MMORPGs, and the effects that participation in these virtual worlds has on older adults' day-to-day lives and socio-psychological wellbeing, is an important contribution as society strives to improve quality of life and maintain long-term independence for older adults.

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References

1. Kaufman, D.: Aging well: can digital games help? Overview of the project. In: Presented at the World Social Science Forum, Montreal, QC (2013)
2. Cohen, S., Willis, T.A.: Stress, social support, and the buffering hypothesis. Psychol. Bull. **98**, 310–357 (1985)
3. Putnam, R.D.: Bowling Alone: The Collapse and Revival of American Community. Simon & Schuster, New York (2000)
4. Singh, A., Misra, N.: Loneliness, depression and sociability in old age. Ind. Psychiatry J. **18**(1), 51–55 (2009). doi:10.4103/0972-6748.57861
5. Mendes de Leon, C.F.: Social engagement and successful aging. Eur. J. Ageing **2**(1), 64–66 (2005). doi:10.1007/s10433-005-0020-y

6. Eisenberger, N.I., Taylor, S.E., Gable, S.L., Hilmert, C.J., Lieberman, M.D.: Neural pathways link social support to attenuated neuroendocrine stress responses. NeuroImage **35** (4), 1601–1612 (2007). doi:10.1016/j.neuroimage.2007.01.038
7. Golden, J., Conroy, R.M., Lawlor, B.A.: Social support network structure in older people: underlying dimensions and association with psychological and physical health. Psychol. Health Med. **14**(3), 280–290 (2009). doi:10.1080/13548500902730135
8. Ducheneaut, N., Moore, R.J., Nickell, E.: Virtual "third places": a case study of sociability in massively multiplayer games. CSCW **16**(1–2), 129–166 (2007). doi:10.1007/s10606-007-9041-8
9. Ducheneaut, N., Moore, R.: The social side of gaming: a study of interaction patterns in a massively multiplayer online game. In: Proceedings of the CSCW 2004, pp. 360–369. ACM Press, New York (2004)
10. Barnett, J., Coulson, M.: Virtually real: a psychological perspective on massively multiplayer online games. Rev. Gen. Psychol. **14**(2), 167–179 (2010). doi:10.1037/a0019442
11. Dickey, M.D.: Game design and learning: a conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. ETRD **55**(3), 253–273 (2007). doi:10.1007/s11423-006-9004-7
12. Yee, N.: Motivations for play in online games. Cyberpsychol. Behav. **9**(6), 772–775 (2006). doi:10.1089/cpb.2006.9.772
13. Schiano, D.J., Nardi, B., Debeauvais, T., Ducheneaut, N., Yee, N.: A new look at World of Warcraft's social landscape. In: Proceedings of the 6th International Conference on the Foundations of Digital Games, FGD 2011, pp. 174–179. ACM, New York (2011)
14. Cole, H., Griffiths, M.D.: Social interactions in massively multiplayer online role-playing games. Cyberpsychol. Behav. **10**(4), 575–583 (2007). doi:10.1089/cpb.2007.9988
15. Whippey, C.: Community in World of Warcraft: the fulfilment of social needs. Totem Univ. W. Ontario J. Anthropol. **18**(1), 49–59 (2011)
16. Williams, D., Ducheneaut, N., Xiong, L., Zhang, Y.Y., Yee, N., Nickell, E.: From tree house to barracks: the social life of guilds in World of Warcraft. Games Cult. **1**(4), 338–360 (2006). doi:10.1177/1555412006292616
17. Yee, N.: The psychology of MMORPGs: emotional investment, motivation, relationship formation, and problematic usage. In: Schroeder, R., Axelsson, A. (eds.) Avatars at Work and Play: Collaboration and Interaction in Shared Virtual Environments, pp. 187–207. Springer, London (2006)
18. Visser, M., Antheunis, M.L., Schouten, A.P.: Online communication and social well-being: how playing World of Warcraft affects players' social competence and loneliness. J. Appl. Soc. Psychol. **43**, 1508–1517 (2013). doi:10.1111/jasp.12144
19. Kirby, A., Jones, C., Copello, A.: The impact of massively multiplayer online role playing games (MMORPGs) on psychological wellbeing and the role of play motivations and problematic use. Int. J. Ment. Health Addict. **12**(1), 36–51 (2014). doi:10.1007/s11469-013-9467-9
20. Dupuis, E.C., Ramsey, M.A.: The relation of social support to depression in massively multiplayer online role-playing games. J. Appl. Soc. Psychol. **41**(10), 2479–2491 (2011). doi:10.1111/j.1559-1816.2011.00821.x
21. Trepte, S., Reinecke, L., Juechems, K.: The social side of gaming: how playing online computer games creates online and offline social support. Comput. Human Behav. **28**(3), 832–839 (2012). doi:10.1016/j.chb.2011.12.003
22. Domahidi, E., Festl, R., Quandt, T.: To dwell among gamers: investigating the relationship between social online game use and gaming-related friendships. Comput. Hum. Behav. **35**, 107–115 (2014). doi:10.1016/j.chb.2014.02.023

23. Activision Blizzard: Activision Blizzard announces record fourth quarter and calendar year 2011 Earnings (2012). http://files.shareholder.com/downloads/ACTI/2573699436x0x541685/787ea4e2-d928-4139-8ae3-4e37250d2443/ATVI_News_2012_2_9_General.pdf
24. Ristau, S.: People do need people: social interaction boosts brain health in older age. Generations **35**(2), 70–76 (2011)
25. Simmel, G.: The sociology of sociability. Am. J. Sociol. **53**(3), 254–261 (1949)
26. Shen, C.: Network patterns and social architecture in massively multiplayer online games: mapping the social world of EverQuest II. New Media Soc. **16**(4), 672–691 (2014). doi:10.1177/1461444813489507
27. Shen, C., Williams, D.: Unpacking time online: connecting internet and massively multiplayer online game use with psychosocial well-being. Comm. Res. **38**(1), 123–149 (2011). doi:10.1177/0093650210377196
28. Williams, D.: The mapping principle, and a research framework for virtual worlds. Commun. Theor. **20**, 451–470 (2010). doi:10.1111/j.1468-2885.2010.01371.x
29. Nardi, B., Harris, J.: Strangers and friends: collaborative play in World of Warcraft. In: Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work, CSCW 2006, pp. 149–158. ACM, New York (2006). doi:10.1145/1180875.1180898
30. Shen, C., Monge, P., Williams, D.: Virtual brokerage and closure: network structure and social capital in a massively multiplayer online game. Comm. Res. **41**(4), 459–480 (2012). doi:10.1177/0093650212455197
31. Freeman, L.C.: Centrality in social networks conceptual clarification. Soc. Netw. **1**(3), 215–239 (1978–1979). doi:10.1016/0378-8733(78)90021-7
32. Steinkuehler, C.A., Williams, D.: Where everybody knows your (screen) name: online games as “third places”. JCMC **11**(4), 885–909 (2006). doi:10.1111/j.1083-6101.2006.00300.x
33. Smith, A.: Older adults and technology use: adoption is increasing, but many seniors remain isolated from digital life. Pew Research Center, Washington, DC (2014). http://www.pewinternet.org/2014/04/03/older-adults-and-technology-use/38
34. Gell, N.M., Rosenberg, D.E., Demiris, G., LaCroix, A.Z., Patel, K.V.: Patterns of technology use among older adults with and without disabilities. Gerontologist **55**(3), 412–421 (2015). doi:10.1093/geront/gnt166
35. Hays, R.D., DiMatteo, M.R.: A short-form measure of loneliness. J. Pers. Assess. **51**(1), 69–81 (1987)
36. Mirowsky, J., Ross, C.E.: Age and depression. J. Health Soc. Beh. **33**(3), 187–205 (1992)
37. Zimet, G.D., Dahlem, N.W., Zimet, S.G., Farley, G.K.: The multidimensional scale of perceived social support. J. Pers. Assess. **52**(1), 30–41 (1988)
38. Cohen, J.: Statistical power analysis for the behavioral science, 2nd edn. Lawrence Erlbaum, Hillsdale (1988)
39. De Schutter, B.: Never too old to play: the appeal of video games to an older audience. Games Cult. **6**(2), 155–170 (2011). doi:10.1177/1555412010364978
40. Tomaka, J., Thompson, S., Palacios, R.: The relation of social isolation, loneliness, and social support to disease outcomes among the elderly. J. Aging Health **18**(3), 359–384 (2006). doi:10.1177/0898264305280993
41. Ernst, J.M., Cacioppo, J.T.: Lonely hearts: psychological perspectives on loneliness. Appl. Prev. Psychol. **8**(1), 1–22 (1999). doi:10.1016/S0962-1849(99)80008-0
42. Heylen, L.: The older, the lonelier? Risk factors for social loneliness in old age. Ageing Soc. **30**(7), 1177–1196 (2010). doi:10.1017/S0144686X10000292

43. Stedman's Electronic Medical Dictionary: Depression. Wolters Kluwer, Alphen aan den Rijn, Netherlands (2006)
44. Cooper, H., Arber, S., Fee, L., Ginn, J.: The Influence of Social Support and Social Capital on Health: A Review and Analysis of British Data. Health Education Authority, London (1999)
45. Zhang, F., Kaufman, D.: The impacts of social interactions in MMORPGs on older adults' social capital. Comput. Human Beh. **51**, 495–503 (2015). doi:10.1016/j.chb.2015.05.034

A 21st Century Teaching and Learning Approach to Computer Science Education: Teacher Reactions

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Abstract. This paper describes a pilot study to evaluate its use for teacher Continuing Professional Development (CPD) in Computer Science (CS) using the Bridge21 model, a particular model of 21st century teaching and learning. A range of introductory Computer Science workshops are evaluated that include topics such as; Computational Thinking, Scratch, Raspberry Pi and Python. This paper includes a detailed look at the generalized activity model used in all Bridge21 activities. Combining the Kirkpatrick training evaluation theory with ethnographic methods the researchers analyzed qualitative and quantitative data gathered from 110 in-service teachers whom attended 9 CS CPD workshops. Using the Kirkpatrick framework as a taxonomy with which to code data relating to (a) teachers initial reactions towards the workshops and (b) intentions towards use of the Bridge21 model for supporting CS classroom delivery. Findings indicate that teachers' initial reactions towards the programme were positive and that teachers intend to use the model in their classroom.

Keywords: Teacher continuing professional development · Computer science · Evaluation · 21st century learning

1 Introduction

Current research highlights the need to understand what supports post-primary Computer Science teachers' need to deliver lessons which encourage their students become more active in their learning [9]. Computing lessons provide rich environments teachers can use to help their students develop content knowledge and skills applicable to real world contexts [16]. Problem based activities enable students to develop a deeper understanding of educational phenomena [33]. Developing problem solving skills is perceived as a core component of computer science education [11]. Incorporating problem solving activities into computing lessons [26] may in turn help teachers help their students learn computing and encourage them to become more active learners [13].

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1.1 Educational Context

This study is situated within the evolving context of 21st century education, in which teachers are increasingly adopting student-centred, technology mediated approaches to instruction [1]. Teacher adoption of these methods across second level education coincides with the emergence of the Computer Science (CS) curricula in a number of European countries including the United Kingdom [4] and the Republic of Ireland [22]. Teachers without formal qualifications in computing, perceive computing as a complex subject to teach and a difficult subject for students to learn [34]. Hence there is a need for innovative CS CPD programmes to empower teachers to meet the challenges they face in mastering CS content and developing appropriate strategies for transforming the teaching of CS in their schools [29].

Paper Structure. The remainder of this paper is structured as follows. The literature review sets up the argument supporting use of two research questions to explore the effectiveness of a social constructivist approach to Computer Science (CS) Continuing Professional Development. The proceeding methodology and data analysis sections, describe the evaluation framework and data processing procedures used to gather and analyse data according to the research questions. The findings and discussion section brings together results clustered into themes to explore the implications of using a social constructivist approach to CPD delivery for CS teachers. The concluding section summaries the findings and suggests areas for further research.

2 Literature

21st century learning is a pedagogical move from didactic, curricula centric, teacher-centred methods of delivery [6] towards facilitated, student-centred methods of instruction [24]. A 21st century approach to teaching involves the use of instructional techniques such as orchestration and facilitation to help the learner construct meaning and understanding by themselves [14]. Orchestration and facilitation methods incorporate the use of social learning protocols such as peer based learning, social interaction, and social discourse to help learners move towards greater learning autonomy [32]. An increase in learner autonomy may result in the gradual withdrawal of teacher-centred delivery methods [20]. Changing the instructional dynamics of the classroom to support 21st century teaching and learning is somewhat complex [27] and there are those who argue against the use of 21st century models [30].

2.1 Teaching Computer Science in the Republic of Ireland

As stated earlier a number of education systems are promoting the inclusion of CS at second level. In the Republic of Ireland, short courses in Digital Media [23] and Coding [22] are available for the first time in schools across the first three years or junior cycle levels (ages 12–15) of the curricula. These courses promote project work using a wide range of digital media including coding which aim to help learners develop expertise in the design, construction and implementation of computing generated artefacts.

The syllabi provided by the NCCA are exemplars and can be adapted by the teacher or used as a guide. However, despite the introduction of these new courses there is limited CPD available to teachers that targets the type of content as well as the 21st century approach to learning that is also promoted in these courses.

2.2 Bridge21 Pedagogy

Bridge21 is a pragmatic, pedagogical model of 21st century teaching and learning, elements of which include team-based, project orientated, technology-mediated activities [18]. The model is currently used by post-primary teachers across a number of schools, in subjects ranging from history [25] to mathematics [3]. The essential elements of the Bridge21 learning model are: (1) technology-mediated learning, (2) project based activities, (3) structured team-based pedagogy, (4) recognition of the social context of learning and (5) facilitation, guiding and mentoring, with teachers orchestrating these activities [8].

2.3 Bridge21 Activity Model

The Bridge21 Activity Model is partially inspired by ideas on Design Thinking [5] consists of several sequential steps which form the basis of each lesson.

The Prelude. The prelude is made up of a number of optional activities. Depending on the group dynamic (have they previous experience working together or in teams?) they may not be necessary. They are however recommended for groups new to teamwork and if the group is not familiar with each other.

Set-Up. The set-up activities are usually employed when the group is new to team work and does not know each other. It also provides an opportunity for team formation, a task that will be at the start of every Bridge21 activity.

Ice Breaker. Helps the members of the group to get to know each other and start intra-group communication. Ice-breaking activities often focus on sharing personal information such as names, hobbies, etc.

Team Selection/Formation. Learning models that seek to encourage high levels of student engagement and intrinsic motivation typically embrace collaboration and teamwork. The theories of Piaget and Vygotsky highlight the importance of the interaction between social, affective and cognitive states in a student's development and learning. Vygotsky's "more able other" identified the peer as a key figure in learning. With teamwork the pool of "more able others" includes all team members and in a project based approach different team members may be able to play that role at different stages in the process as peers learn from each other.

Warm-up and Divergent Thinking Activity. The general divergent thinking activity is used to warm up the teams and get them thinking creatively. If a group seems sluggish or unmotivated this can be a good activity to get them thinking and engaged with the activity.

Investigate. Depending how guided an activity teachers wish to make the activity, this is an opportunity for the teachers to provide the students with a primer in some domain knowledge, or get the teams to explore the domain knowledge as a research activity. Finally in this section the teams define the problem or context of their activity in preparation for the planning phase which follows. The planning phase gets the teams to plan how they are going to achieve what they have defined as their problem context. Here teams allocate roles, resources, tasks lists and schedule the activities involved. The following phases are used to investigate, ideate, research and define the problem context, which is defined by the teachers.

Problem Context/Brief. Here the teachers explains the problem context or the activity brief, outlining the activity. The topic should be focused enough that the teams are clear about what they are working on, but broad enough that they can take ownership and tackle the topic creatively.

Divergent Problem Thinking. Divergent thinking based on the problem context provides an opportunity for the teams and wider group to explore and think laterally about the problem. It is at this point that they get to think creatively about the problem context. It is important that this stage remains playful and gets the whole group "thinking outside the box". It is through this creative activity that the teams and individuals take ownership of problem.

Content Knowledge Development Exercise. This is an optional step that may not be applicable to all activities. If the group requires more content/domain knowledge or experience in skills needed during the main activity, exercises or mini-activities can be used to develop the necessary skills and/or knowledge. It can be combined with the research step which follows, where a priming activity is used to generate questions that may be answered through online research.

Research. This optional step can be used for the teams to gain more background information about the problem space. They can expand the ideas developed during the divergent problem thinking step or use those ideas as initial search queries to develop further ideas. This is a good opportunity to explain best practices in ICT information access (safely browsing the web, evaluating sources etc.)

Problem Refinement/Framing/Design. Here the teams are asked to focus and refine their problem context so as that the main activity has a well-defined problem scope. The teams should develop at least three potential directions (common design technique) at first and critically analyse them and pursue the one they consider the most interesting and plausible/practical considering the constraints (time and resources) course.

Planning. The planning stage is an opportunity for the teams to develop their plan of action. Here they develop a comprehensive task list and timeline or schedule for their proposed implementation. They then assign the tasks, roles and resources to individual team members (team members can share tasks and resources, but one team member should be encouraged to take responsibility for the task).

Develop Task List/Outline. A comprehensive task list should be developed based on the refined problem context that concluded the investigate phase. The teacher may provide a template that helps scaffold the activity and implementation (e.g. using a story boarding and crew roles templates for video production). The goal here is to get the teams taking responsibility of the activity and thinking practically about how they are going to achieve their goals.

Task, Role, Scheduling, Resource Assignment. Building on the task/overview developed in the previous step, further templates may be used by the teams to schedule tasks, and assign tasks, roles and resources to the various team members. Alternatively teams may be tasked with developing their own templates with teacher guidance. This step develops the student's sense of responsibility and appreciation of resources necessary to complete tasks.

Create. Now begins the main activity. The create phase is where the artefact and presentation is developed through an iterative/cyclical process of execute, test and reflect. Execution see them executing their plan that they developed in the previous step. Regularly (20–50 min, depending on activity duration) the team leader and/or teacher should have a brief review session with their team members as to how the plan is working out, and whether there needs to be corrective action taken. This should be followed by a quick individual reflective session focusing on personal perceptions of their process, progress and any learning opportunities and/or enlightenment. This cycle should be repeated until all allocated time has been utilised, later cycles may be used for improvement and refinement and further skill development.

Execute/Create. The execute/create step is where the teams task list/outline is put into action, there is opportunity to revise the plan in the steps that follow, should time allow for it.

Review/Evaluate/Test. This step provides the team with the opportunity to review how their actions are or are not meeting with their task list and schedule. It also provides an opportunity for the team to access their initial assumptions and revise where necessary.

Reflect. Reflect on their progress and process, particularly focusing on managing themselves, staying well, communicating, being creative, working with others and managing information and thinking.

The Finale. The finale is the culmination of the main activities work. Here the teams present their work to the teacher and whole group. Each member should contribute to the final presentation, but they may elect a member to handle the main presentation (does not necessarily have to be the team leader).

Evaluation and Feedback. This is an essential phase of the process, where the teams present their work and reflect on their learning throughout the entire activity.

Presentation. The central reason for the presentation is to develop both communication skills and confidence with public speaking. The teams should be encouraged to not only describe the output but to also comment on what role each team member played in the process and lessons learned during the activity.

Reflection. Here both teams and individuals reflect on their experiences using the provided templates. It provides an opportunity for the team members to reflect on how they worked together and what they personally learnt during the activity. Emphasis should be but on using the outputs from this step to improve future learning scenarios.

Whole Group Discussion. This is the final step. Here the whole group discusses what they learnt, found difficult, enjoyed or would recommend doing differently if the activity was to be repeated. Essentially it is a sharing of the lessons learned by all involved and provides an excellent opportunity for the teacher to get feedback from the students about how they found the activity.

2.4 Bridge21 CS CPD

In response to the twin challenges of empowering in-service teachers to up-skill in order to teach CS and the need to gain expertise in 21C teaching and learning strategies the authors' institution has launched a Post Graduate Certificate in 21st century Teaching and Learning. This certificate is in its first year of delivery with 113 teachers registered on the programme. Modules are delivered on campus during weekends and school holidays to offer maximum attendance. The programme consists of 12 modules, 4 of which are compulsory, with the remaining 8 as optional modules. 6 modules relate to computing and each is delivered using the Bridge21 learning and activity models [7].

The ***Digital Media Literacy*** module provides an introduction to the Bridge21 model, while also supporting the development of digital media editing skills and providing examples of how to use the Bridge21 model across a range of curriculum subjects. ***Problem Solving for the 21st century*** provides the teachers with a set of activities that are inspired by CS unplugged [2] in which algorithmic thinking is approached without the use of a computer. ***Introduction to Programming*** uses Scratch to introduce basic programming concepts through animation. ***Intermediate Programming*** through game design again utilizes Scratch to explore advanced concepts, such as events and concurrency. ***Exploring Computer Systems*** [7] uses the Raspberry Pi in conjunction with the Python programming language to introduce embedded systems and inputs and outputs. ***Advanced programming*** is introduced via the Python text-based programming language, which is used to solve a number of mathematical tasks.

3 Research Questions

Two exploratory questions underpin the research designed to explore teacher reactions. Question one explored the extent to which the Bridge21 model proved effective for the delivery of the CS CPD programme, while question two sought to explore the extent to which teachers intend to use the Bridge21 model in their classroom delivery. The next section details the methods and evaluation framework used to explore these questions.

4 Methodology

The evaluation framework used in this study was adapted from a training programme evaluation model used to explore corporate training programmes [15]. The researchers adapted this framework to measure educational outcomes or objectives relating to the provision of the Bridge21 CS CPD programme [12]. Learning objectives relate to the participants ability to understand and perform specific computer science tasks [21], and use elements of the Bridge21 model in the context of their classroom teaching. Each module exposes teachers to the Bridge21 learning and activity models and teachers are encouraged to use a similar approach in teaching CS.

4.1 Workshop Delivery

The following procedures were followed to address the research questions. The Bridge CS CPD programme comprised of 9 workshops delivered in Trinity College Dublin over the 2013/2014 academic year. Workshop delivery occurred on Saturdays and school holidays to facilitate maximum participant attendance. Workshops were free to attend and run on demand, resulting in some workshops delivered once, while others were delivered twice. A total of 9 workshops were delivered during the study period, generating a combined total of N = 110 attendances. Each workshop commenced at 10 am and concluded at 3.30 pm. Participants attended the workshops of their own accord, and thus samples where self-selecting. Participant profiling revealed that some participants identified as having prior CS delivery experience while others identified as being new to computing.

Participant Profiling Data. Participant profiling data was gathered as follows. Prior to attending the workshops, participants were invited to complete an on-line pre-questionnaire. The questionnaire asked participants to provide details relating to (1) prior computing expertise and details relating to (2) current computing delivery in schools. All pre-questionnaire questions were optional and a total of 51 responses from 110 participants generated a 46 % completion rate.

4.2 Kirkpatrick Adaptation

The Kirkpatrick framework operates over four levels. The first two levels refer to the training offering itself while the subsequent two levels focus on behavior and its impact. Level 1 gathers participant reactions to training and level 2 seeks evidence of learning through the assessment of skills, attitudes and content knowledge acquired in the context of the training environment. Level 3 seeks evidence of behavioral changes as a result of the training, and Level 4 seeks results based on evidence on the use of the training within the context of the workplace environment. All levels are sequential in so far that data obtained from one level, informs data collection in the next, maintaining a 'chain of evidence' across data sets. Table 1 describes each level and its purpose.

Table 1. Kirkpatrick model.

Level	Description	Purpose	Location
Level 1 – Reactions	Reactions to the training	Gather evidence relating to participant reactions to the training	Training environment
Level 2 – Learning	Learning by the participants	Evidence of learning through the assessment of skills, attitudes and content knowledge	
Level 3 – Behaviour	Behavioural changes	Evidence of changes as a result of the training	Workplace environment
Level 4 – Results	Evidence of workplace change	Results based on evidence of the use of the training in the workplace	

Level 1 – Reactions Evaluation. This paper analyses the results of data obtained from the distribution of a single page, hard copy Level 1 Reaction Instrument issued to individual participants at the end of each workshop. The reaction instrument contained a combination of 12 closed numeric questions and 4 open qualitative questions, each of which were adapted from an existing Kirkpatrick Level 1 Training Evaluation Form [17]. This instrument was adapted to gather participant reactions towards the workshop design, role of the facilitator, suitability of facilities and usefulness of the topics covered. Additional questions included an improvements indicator regarding more/less time spent on CS topics, participant reactions towards the use of the Bridge21 model for learning CS, perceived changes to practice as a result of the CS CPD intervention and perceived use of the model for CS delivery.

4.3 Data Gathering Procedures

Participants opted to attend workshops on their own accord, and thus were self-selecting. At the start of each workshop the research team briefed participants about the evaluation process and issued each participant with an ethics consent form and information sheet. Participants were then invited to counter sign copies to consent to the use of their data for research publication, or opt out and leave the forms blank. A total of N = 63 forms, from 110 attendances from 9 CS CPD workshop deliveries were received during October 2013 to May 2014. An average of 12 individuals attended each workshop, with some individuals attending one workshop, and others attending one or more workshops over the evaluation period. This paper includes responses from participants whom provided written consent to include their written accounts in published research.

5 Data Analysis

The researchers adopted an ethnographic approach to the reconstruction of research findings [10]. This approach views the transcription and reconstruction of text responses as a form of social discourse. A transcribed account is 'limited insofar as it produces a partial perspective' [28] of phenomena. This is because 'the ethnographer interprets that which he or she observes' [28]. In light of these limitations, we argue that such accounts, while subjective, yield rich and meaningful descriptions which are reconstructed from the observation of phenomena at a particular time and place [31]. This study brings together narrative segments from small samples so these accounts may be unsuitable for theoretical or statistical generalization.

5.1 Quantitative Coding

Numeric data from five Likert quantitative scales (arranged 1 *Strongly Agree,* to 7 *Strongly Disagree*) were processed using SPSS statistical processing software. SPSS calculated an average of means per scale then produced a total percentile score per scale.

5.2 Qualitative Coding

All qualitative written responses were manually and electronically transcribed, coded then stored in a searchable database. Three iterations of manual coding were performed against transcribed text responses. This process resulted in the production of 64 textual codes from a total number of 253 database records. Comparative coding was used to reduce the qualitative data set. Comparative coding or analytical induction seeks to extract dominant or contradictory themes from the process of data analysis [19]. This technique underpinned the generation of four themes from the coded data set. Table 2 illustrates the iterative cycles used to reduce the overall data set.

Table 2. Coding process.

Total data records	253
Inductive coding cycle 1	173
Deductive coding cycle 1	104
Deductive coding cycle 2	64
Themes	4

Themes. Four qualitative themes emerged from the comparative coding process. The themes of '*learner autonomy*' and '*content knowledge'* relate to the research question one and the effective use of the Bridge21 model for the provision of CS CPD programme. While the themes of '*lesson planning*' and '*orchestration and facilitation,*' relate to research question two and explore ways in which participants intended to use the Bridge21 model in the context of their own CS delivery in schools.

6 Findings and Discussion

This section is organized as follows. Sections 6.1 and 6.2 start with some background profiling data on participants such as prior computing expertise and current delivery practices in schools. Section 6.3 discusses statistical analysis of participant reactions towards the workshop design, role of the facilitator, and suitability of facilities and usefulness of the topics covered. The next section (Sect. 6.4) discusses participants' reactions towards the effectiveness of the Bridge21 model for the delivery of the CS CPD programme. Finally, Sect. 6.3 discusses participant intentions towards using the Bridge21 model in their CS delivery.

6.1 Prior Computing Expertise

In summary, 65 % of participants whom completed the pre-questionnaire prior to attending the Bridge21 CS CPD programme identified as female (N = 33 responses), which the remaining 35 % identifying as male (N = 18 responses). Also, 23 % (N = 12 responses) of participants identified as having prior exposure to the Bridge21 models. In addition, 70 % (N = 39 responses) of the same participant sample also identified as not having a 3rd level qualification in computing. However, 54 % (N = 27 responses) of the sample identified as currently teaching computing in schools prior to attending the CS CPD programme. This initial profiling data captured a higher proportion of women attending the workshops and a low percentage of participants with prior expertise in using the Bridge21 model. The data reports a high percentage of participants teaching computing. This indicates drive and commitment by teachers towards making computing accessible to students via the delivery of extra curricula activities.

6.2 Current Computing Delivery in Schools

Analysis of the same sample population (N = 51 responses) yielded the following results in relation to current computing delivery. A total of 75 % (N = 38 responses) identified as running a computer programming club in their schools. The most common tools used with students included Scratch (+ combination of other tools such as Python, App Inventor, Raspberry Pi, Alice, Java Script) – with 94 % of participants using a combination of these with students both in computing classes, or in the context of the delivery of other subjects (N = 48 responses). One participant, who taught math, commented that that they liked to use '*tools like Geogebra online, Wikis online, MS Excel, MSOffice, MS Power Point, and much more. In ICT (Information Communication Technologies), I have used scratch.*' Another participant, whom taught History, commented that they liked to use '*Edmodo as a tool for more instantaneous feedback for students. I use Minecraft in History in order to create virtual worlds. I use Wikis for group projects/ collaboration.*' Participants also identified professional memberships and conferences run by organizations such as Computers in Education Society of Ireland (www.cesi.ie) - as important professional peer supports to assist with CS delivery.

6.3 Overall Reaction

This section explores participant reactions' towards the success of the workshops in terms of providing an overall satisfaction rating, a rating for the design of the workshops, a rating for the use of facilitation as a delivery method and a rating relating to the usefulness of workshop activities/content.

Workshop Satisfaction. Two thirds or 86.16 % response rate (from N = 63 individual participants) strongly agreed that they were satisfied with the Bridge21 CS CPD workshop experience and that the workshops were worth attending. Half of those participant responses (49 %) were awarded the strongest overall rating in terms of levels of satisfaction towards the programme (1 = Strongly Agree). In terms of expressing their satisfaction with the CS CPD training intervention, one participant commented that the workshop experience would '*help me integrate these topics across (the) curriculum that I teach'* while another participant stated that the workshop experience had given them a '*good understanding of how to apply computing to other subjects*'. Another participant highlighted the possibility of using elements of the Bridge21 model to introduce autonomous learning into the classroom '*I might be more inclined to let students problem solve on their own.*' These comments highlight intentions towards using the Bridge21 model to support CS delivery in the classroom.

Workshop Design. The majority of participants were satisfied with the design of the workshops (77.06 % response rate). One participant expressed that they intended to '*use the workshop model*' in on return to classroom teaching, while another participant stressed that they wanted to use elements of the workshops to '*bring in a structured course (computing) into teaching*'. Both these participants indicate incorporating elements of the Bridge21 model into their classroom delivery.

Facilitation Methods. Participants also reacted favourably to the use of facilitation as a method for delivering CS to professional in-service teachers (89.24 % response rate). One participant commented that the method of delivery used in the workshops (i.e. the use of mentoring and facilitation) had *'helped me to understand the basics (of computing) and focus on them for the benefit of my students.* This comment highlights an initial acceptance towards using facilitation and peer mentoring for exploring CS.

Workshop Activities and Content. Participants also registered a positive response rate (87.16 %) towards use of computing examples and practical activities used during the workshops. One participant liked the use of '*teamwork and collaboration'* for learning computing while another participant explained the Bridge21 model provided a '*good technique for team teaching.'* Another participant commented that workshop experience had enabled them to learned *'new IT skills'* but that they had also learned a *'new approach to (teaching) team activities'*. These comments highlight participant reactions towards using 21st century pedagogy for learning new methods and CS content.

6.4 Reactions Towards Bridge21 Model Effectiveness for CS CPD

This section explores participant reactions towards use of the Bridge21 model for CS CPD.

Content Knowledge. Again, participants reacted positively towards the use of the Bridge21 model for learning computer programming languages and as an aid to understanding how to apply computing concepts. One participant commented that they had obtained a '*better knowledge of scratch*' while another commented that they had learned '*a better understanding of python and similarities to scratch*'. In contrast, one participant commented that they would need *'more training in scratch, (as) I wouldn't be confident to deliver it in class yet.'* Two other participants shared this view. One participant stated that they would '*need more workshops*' to use Scratch in their classroom teaching, while a second participant agreed with this view and commented that they also did not yet '*feel confident enough to teach programming*'- indicating a need for more training in order to deliver Scratch programming.

Other participants registered an increased level in the confidence in teaching computer programming, as a result of the workshop experience. One participant commented that they felt they had obtained '*more confidence in (using) computers in classroom,*' while another participant stressed that they would be able to '*use scratch independently,*' as a result of attending a scratch workshop. Another participant commented that 'I *will be integrating scratch in my classroom,*' while another participant indicated that they '*would try to introduce this language (*Scratch) *to student's that are interested in coding.*' These examples highlight that some participants were satisfied with a single training intervention, while others required further workshops in the same topic areas.

Using the Bridge21 model for the delivery of CS CPD workshops also offered participants the opportunity to experience a '*different approach to teaching computers.*' This experience enabled participants to think about how '*to introduce teamwork in computer classes*'. Another participant stressed that the workshop experience had helped them *'to keep my teaching in scratch programming up to date and relevant to students I teach'*. Another participant expressed that the workshop experience had enabled them to '*extend (their) knowledge of raspberry pi technologies so that I may use it successfully in the classroom.*' One participant also concurred with this statement stressing that the workshop experience had '*introduced me to the possibility of using the raspberry pi.*' The Bridge21 workshop experience appeared to have helped participants engage with computing concepts and programming languages, helped participants identify and address potential knowledge gaps and helped participants explore how they might adopt a Bridge21 approach to teaching CS in their schools.

Learner Autonomy. The Bridge21 CS CPD workshop experience also provided participants with the opportunity to explore the experience of 'autonomous learning'. One participant commented that the workshop experience provided a supportive training environment which enabled them to '*approach group work in a different manner (mistakes are ok!).*' Another participant commented that the workshop experience had help them to '*be more open minded, (and) adaptable*' when learning new concepts, such as computer programming. Another participant stressed that the workshop experience had enabled them to *'feel more comfortable about working with scratch'* with a subsequent participant commenting that the experience enabled them to reach a level of expertise in which they felt '*able to pass on some knowledge of what rasp pi is about'* to their students, on return to the school classroom.

Another participant reflected on feeling empowered to '*promote self-directed learning'* with their students, while another participant felt equipped to begin '*exploring possibilities'* as to how they might delivery computing in the classroom using the Bridge21 model. One participant stressed that the workshop experience provided a platform through which to help their students engage with a variety of learning activities such as '*collaboration, the effect of group work, the diversity of ideas, and filtering*' – techniques aimed at helping learners explore and share their understanding of ideas.

However not all participants responded favourably to the experience of autonomous learning. One participant commented that delivering more open ended learning experiences required consideration of the '*importance of preparation materials'* while another expressed a need for more formal '*input on the tools'* used during computing and programming activities. Another participant stressed that professional development needs to '*give us the tech skills rather than just "do it" tasks'* highlighting unease at learning computing through peer supported, socially mediated group working.

6.5 Intended Use of the Bridge21 Models for Teaching CS

This section explores participant intentions towards the use of the Bridge21 model for supporting classroom delivery.

Lesson Planning. The majority of participants intended to use computing concepts taught in the workshop setting combined with elements of the Bridge21 model on return to classroom teaching. One participant intended to '*use python to consolidate maths problem solving*,' while another participant aimed to '*use the raspberry pi to teach python'*. Another participant commented that they had learned '*how to develop and define a working algorithm'* and intended to use elements of the Bridge21 model to help them teach *'Computational Thinking not just in IT as I had done previously'*. Another participant commented that they intended to use aspects of the Bridge21 model '*in classroom activities*,' but another participant stressed that they intended to use the model to help them *'use group work more carefully.*' Interesting, one participant commented that the workshop experience enabled them to '*create lesson plans and facilitate young people using scratch.'*

Exposure to the Bridge21 model had also helped participants to think about how they might adjust their delivery, to help their students engage with CS. One participant commented that the workshop experience had given them supports to think about creating 'a *module for TY (Transition Years)/1st Years' on programming.'* Another participant stated that the workshop experience had given them '*ideas on how to introduce programming to my students'*. One participant commented that the workshop experience had given them '*a better understanding of how I would utilise various resources in the classroom,'* for teaching computing. A number of participants also registered the intention to '*integrate scratch in some lessons,'* to develop '*short courses* *in IT and Transition Year IT programming'* with one participant indicating that they '*might talk to principle about adopting the model*' in the context of their classroom teaching. Another participant shared this view and indicated that they also planned to '*adopt the model in classroom as well.'*

In terms of using the Bridge21 model to support the delivery of CS, one participant stated that the workshop experience had equipped them sufficiently to '*introduce game design to my classes and develop a module on it,'* while another participant wanted to use elements of the models to '*let students work independently and figure out the coding problems,'* with a third indicating that they intended to use the models as a mechanism to help them '*introduce more project based group work*' into teaching.

Orchestration and Facilitation. Exposure to the Bridge21 learning model enabled participants to explore how they might adopt or use 21st century teaching methods in their classroom delivery, on return to the classroom. This exposure enabled participants to think about how to *'run group sessions differently.'* One participant reflected that learning how to orchestrate group work is a skill, as '*groups can be successful, but with careful make-up.'* Another participant commented that group working methods can assist in '*keep moving things along,'* while another participant had learned a technique to help them to *'ask more questions of class, (and) give less answers'* as a means of supporting students engage with learning materials. One further participant commented that this approach might create a learning environment for '*pupils in class to help each other.'* Another participant commented that the Bridge21 model provided a mechanism by which to control the *'pacing, input, leave students to it,'* with the aim of giving student learners, time, space and educational supports to explore phenomena.

The Bridge21 CS CPD workshop experience enabled participants to visualize how they might orchestrate learning experiences using the Bridge21 models. One participant commented that they '*could see clearly how it (the Bridge21 model) may be used in a classroom context*' while another participant commented that they might *'experiment with the methodology in class.'* These comments capture an openness to '*try new things with my class.'* The Bridge21 CS CPD workshop experience not only created opportunity for participants to *'try out more teamwork and self-directed teaching'* and '*promote self-directed learning,'* Bridge21 model exposure enabled participants to explore how they might organize learning activities to encourage student autonomy, and try them out before use in class.

In terms of teaching computing and programming, one participant commented that the Bridge21 CS CPD workshop experience had enabled them to reflect on the issue that '*programming is possible but it takes a lot of time.'* Two further participants echoed that when learning to program it is important *'not give up as easily,' or to 'never give up.'* Another participant shared this view and commented, the Bridge21 model may be perceived a way to help teachers *'talk less in class and get pupils to do more.'* This comment is situated in the context that 21st century pedagogical models emphasise that it is '*the process not the technology*' which helps the learner achieve their educational and learning goals.

Finally, one participant stressed that '*learning by doing works,'* hinting at the emergence of a sub theme relating to self-directed learning. This is encapsulated in the following participant comment – in which '*learning in order to achieve a specific task and figuring it out is more motivating that just learning because you have to.*' These comments illustrate ways in which the Bridge21 CS CPD workshop experience and use of the Bridge21 pedagogical models provided participants with an experience which enabled them to explore and learn computing concepts, but also with the opportunity to consider how and in what ways they might apply or adapt elements of those experiences in the context of their classroom teaching to help students learn CS.

7 Conclusions

This paper set out to explore the extent to which the Bridge21 model proved effective for the delivery of the CS CPD programme, and to understand the extent to which teachers intend to use the Bridge21 model in their classroom delivery. The Bridge21 model provided a context which enabled teachers to explore computer science from a number of perspectives, whether conceptually through the completion of project work, or practically through participation in hands on coding and programming.

While some participants liked this approach, and felt confident to use what they had learned in the CS CPD workshops in this classroom with their students, a number of teachers expressed the need for further workshops combined with additional training and supports to develop computing expertise, prior to demonstrating CS concepts in front of students. In terms of understanding how to apply CS concepts in the classroom – the Bridge21 models provided teachers with a sequence or structure through which they could explore and think about how to adapt elements of the process for integrating CS into their teaching. In some cases, the model enabled teachers to explore how they might change the social dynamics of the classroom, by implementing learning experiences where the answer to questions may not always be readability available or where the process is used to support learners find the solution to problems by themselves.

The Bridge21 model also provided teachers with the opportunity to not only explore the mechanics of an autonomous learning model, but also to explore how to facilitate the delivery of such a model through participation in group work and team based projects. While reactions were generally positive towards the use of the Bridge21 learning model for the provision of a CS CPD programme, there is still further work needed to look more closely at the way in which the model supports learners engage with CS concepts in the context of workshop delivery.

In terms of using the Bridge21 model to support CS classroom delivery, teachers expressed a range of views in terms of how they intended to use the model in the context of their classroom teaching. While some teachers intended to use elements of the Bridge21 activity sequence to help organise the delivery of CS classes across the curricula, other teachers expressed an interest in using CS concepts, and elements of the Bridge21 models to enhance the delivery of other subject areas. Also, while some teachers interested in teaching CS also aimed to adopt the Bridge21 models to enhance their CS delivery, other teachers looked to implement elements of the model, such as group work and team based activities as a means of helping their students engage more 'autonomously' with the curricula.

7.1 Further Research

This paper started with the suggestion that helping students become 'more active in their learning' lies at the heart of a 21st century approach to teaching and learning. However, teachers also need access to professional development programmes which enable them to upskill and develop techniques they can use with confidence in the context of helping their students take more empowered role in their learning. The Bridge21 CS CPD programme uses a social constructivist approach to CS delivery in an attempt to help teachers meet the demands of the 21st century classroom. The Bridge21 CS CPD programme also seeks to help teachers learn and develop expertise in CS, which may hopefully translate into the classroom in ways which make CS delivery interactive and engaging for both the teacher, and their students. It is with this aim, that further research is planned to explore use of the Bridge21 model as a mechanism for enhancing CS delivery. CS is and remains a difficult subject to teach and learn, and the authors hope that this paper sheds some light on these difficulties, but also successes inherent in using a social constructivist approach to learning CS, in ways compatible with the 21st century school classroom.

Next Steps. This Evaluation Paper Is the First in a Series, Which Seeks to Understand the extent to which social constructivist teaching and learning models enable teachers to empower their students to take a more active role in their learning. This paper explores the first level of the Kirkpatrick framework, in order to understand teacher reactions' towards the Bridge21 CS CPD programme. Level 2 analysis is underway to take a closer look at the impact of the CS CPD workshop experience in helping the same teachers learn computing concepts. The researchers have also initiated Level 3 analysis to determine the extent to which teachers have adapted workshop elements in their subject teaching. It is still too early to draw final conclusions on classroom impact based on the results.

References

1. Beetham, H., Sharpe, R.: Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning. Taylor and Francis, Oxon (2013)
2. Bell, T., Alexander, J., Freeman, I., Grimley, M.: Computer science unplugged: school students doing real computing without computers. New Zealand J. Appl. Comput. Inf. Technol. **13**(1), 20–29 (2009)
3. Bray, A., Tangney, B.: Mathematics, technology interventions and pedagogy-seeing the wood from the trees. In: The CSEDU (2013)
4. Brown, N.C.C., Sentance, S., Crick, T., Humphreys, S.: Restart: the resurgence of computer science in UK schools. ACM Trans. Comput. Educ. (TOCE) **14**(2), 1–22 (2014)
5. Brown, T., Wyatt, J.: Design thinking for social innovation. Dev. Outreach **12**(1), 29–43 (2010)
6. Bybee, R.W., Fuchs, B.: Preparing the 21st century workforce: a new reform in science and technology education. J. Res. Sci. Teach. **43**(4), 349–352 (2006)

7. Byrne, J.R., Fisher, L., Tangney, B.: Computer science teacher reactions towards raspberry Pi continuing professional development (CPD) workshops using the Bridge21 model. In: The IEEE International Conference on Computer Science and Education, Cambridge, UK (2015)
8. Conneely, C., Murchan, D., Tangney, B., and Johnston, K.: 21st century learning–teachers' and students' experiences and views of the Bridge21 approach within mainstream education. In: The Society for Information Technology and Teacher Education International Conference (2013)
9. Cunny, J.: Transforming computer science education in high schools. Computer **44**(6), 107–109 (2011)
10. Denzin, N.K., Lincoln, Y.S.: The discipline and practice of qualitative research. In: Denzin, N.K., Lincoln, Y.S. (eds.) The Landscape of Qualitative Research, pp. 1–42. Sage Publications Ltd., Thousand Oaks (2013)
11. Fee, S.B., Holland-Minkley, A.M.: Teaching computer science through problems, not solutions. Comput. Sci. Educ. **20**(2), 129–144 (2010)
12. Fisher, L.: Evaluating use of the Bridge21 model for teacher continuous professional development (CPD) in computer science (CS). In: 11th European Evaluation Society Biennial Conference (EES), Dublin, IE (2014)
13. Hazzan, O., Lapidot, T., Ragonis, N.: Teaching Methods in Computer Science Education Guide to Teaching Computer Science: An Activity-Based Approach, pp. 91–118. Springer, London (2010)
14. Hein, G.E.: The constructivist museum. J. Educ. Mus. **16**, 21–23 (1995)
15. Kirkpatrick, D.L.: Evaluating: Part of a Ten-Step Process Evaluating Training Programs- The Four Levels, pp. 3–16. Berrett-Koehler Publishers, San Fransisco (1994)
16. Kirkwood, M.: Infusing higher-order thinking and learning to learn into content instruction: a case study of secondary computing studies in Scotland. J. Curriculum Stud. **32**(4), 509–535 (2000)
17. Kristiansen, N.: Making smile sheets count Infoline No. 250402. In: Kirkpatrick D.L. (ed.) The Four Levels of Evaluation Measurement and Evaluation Tips, Tools, and Intelligence for Trainers, 7(1), p. 3. American Society for Training and Development (ASTD), USA (2007)
18. Conneely, C., Lawlor, J., Tangney, B.: Towards a pragmatic model for group-based, technology-mediated, project-oriented learning–an overview of the B2C model. In: Lytras, M.D., et al. (eds.) TECH-EDUCATION 2010. CCIS, vol. 73, pp. 602–609. Springer, Heidelberg (2010)
19. LeCompte, M.D., Schensul, J.J.: Using Constant Comparison and Analytical Induction to Identiy Items Analyzing and Interpreting Ethnographic Data, pp. 75–78. Altamira Press, London (1999)
20. Lier, L.V.: Action-based teaching, autonomy and identify. Int. J. Innov. Lang. Learn. Teach. **1**(1), 46–65 (2007)
21. Medina, J.A., Sanchez, J.J., Garcia-Lopez, E., Garcia-Cabot, A.: Learning outcomes using objectives with computer science students. In: The Proceedings of the 2014 Conference on Innovation and Technology in Computer Science Education (2014)
22. NCCA: Short Course - Coding (2014a). http://www.curriculumonline.ie/Junior-cycle/Short-Courses/Coding
23. NCCA: Short Course - Digital Media Literacy (2014b). http://www.curriculumonline.ie/Junior-cycle/Short-Courses/Digital-Media-Literacy
24. Noonan, S.J.: 21st Century Learners and Pedagogy in Teacher Effectiveness and Learner-Centred Practice How Real Teachers Learn to Engage All Learners, pp. 71–72. Rowman and Littlefield Education, Plymouth (2013)

25. O'Donovan, D.: Enquiry based Learning at Bridge21 (2015). https://sites.google.com/site/enquirybasedlearningatbridge21/home
26. O'Grady, M.J.: Practical problem based learning in computing education. ACM Trans. Comput. Educ. **12**(3), 10 (2012)
27. Petersen, C.I., Gorman, K.S.: Strategies to address common challenges when teaching in an active learning classroom. In: Baepler, P., Brooks, D.C., Walker, J.D. (eds.) Active Learning Spaces, vol. 137, pp. 63–71. Wiley, Hoboken (2014)
28. Rosen, M.: Coming to terms with the field: understanding and doing organizational ethnography. J. Manag. Stud. **28**(1), 1–24 (1991)
29. Sentance, S., Dorling, M., McNicol, A.: Computer science in secondary schools in the UK: ways to empower teachers informatics in schools. In: Diethelm, I., Mittermeir, R.T. (eds.) ISSEP 2013. LNCS, vol. 7780, pp. 15–30. Springer, Berlin (2013)
30. Silva, E.: Measuring skills for 21st-century learning. Phi Delta Kappan **90**(9), 630–634 (2009)
31. Tedlock, B.: Ethnography and ethnographic representation. In: Denzin, N.K., Lincoln, Y.S. (eds.) Handbook of Qualitative Research, pp. 455–486. Sage Publications, Thousand Oaks (1994)
32. Vygotsky, L.S.: Interaction between learning and development. In: Cole, M., John-Steiner, V., Scribner, S., Souberman, E. (eds.) Mind in Society: The Development of Higher Psychological Processes, pp. 79–91. Harvard University Press, London (1978)
33. Wells, G.: Towards a social constructivist model of learning and teaching dialogic inquiry. In: Towards a Sociocultural Practice and Theory of Education, vol. 1, pp. 335–337. Cambridge University Press, Cambridge (1991)
34. Yadav, A., Korb, J.T.: Learning to teach computer science: the need for a methods course. Commun. ACM **55**(11), 31–33 (2012)

Seamless Integration of Knowledge Management and Professional Learning in PRiME

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Abstract. In an organizational context, Knowledge Management (KM) and Technology Enhanced Learning (TEL) have attracted attention over the past years and are meanwhile important tasks to increase competitive advantages of an organization. In practice, however, KM and TEL fields have evolved down separate paths. In contrast to former KM and TEL theories which characterize knowledge as a thing or process, the Learning as a Network (LaaN) theory views knowledge as a personal network. LaaN provides the theoretical foundation for the seamless integration of KM and TEL into one solution for the purpose of increased individual and organizational learning. Driven by the LaaN theory, the Professional Reflective Mobile Personal Learning Environments (PRiME) project aims at the convergence of KM and TEL by following a knowledge-as-a-network approach. PRiME enables the professional learner to harness tacit knowledge and offers continuous knowledge networking at three different layers: the Personal Learning Environment (PLE), the Personal Knowledge Network (PKN) and the Network of Practice (NoP). Continuous knowledge networking results in constant evolution of knowledge leading to personal as well as organizational learning.

Keywords: Knowledge management · Technology enhanced learning · Lifelong learning · Professional learning · Work-integrated learning · Personalized learning · Network learning

1 Introduction

Since its introduction in the early 1990s, Knowledge Management (KM) has always played an important role to increase the productivity of knowledge workers and achieve organizational benefits. Mainly following two major approaches regarding knowledge-as-a-thing on the one hand or knowledge-as-a-process on the other hand, KM could not fulfill the high hopes laid in it. Also, the finding that knowledge is something personal in nature could not help out when Personal Knowledge Management (PKM) came up in the past couple of years [1].

Similarly, over the last decade, Technology-Enhanced Learning (TEL) has been addressed as a possibility to go new ways in education, but as with KM the view of learning as a passive, teacher-driven process where knowledge is viewed

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as an object that can be transferred from the mind of the teacher to the mind of the students precluded a real innovative success. That did not change with the emergence of the Web 2.0 movement which brought up various tools to connect learners and put them in an active role. The traditional pedagogical principles were, however, kept untouched.

In a professional context, despite the recognition of the strong links between KM and TEL, the two fields are still evolving down separate paths. In this paper, we recapitulate the shortfalls of KM and TEL and present the Learning as a Network (LaaN) theory as a new vision of learning defined by the convergence of KM and TEL concepts into one solution. Furthermore, we present a possible application of the LaaN theory in the frame of the Professional Reflective Personal Mobile Learning Environments (PRiME) Project. PRiME focuses on the convergence of the learning and working processes and proposes an integrated KM and TEL framework that offers layered knowledge networking to foster continuous individual and organizational learning.

The remainder of this paper is structured as follows. Section 2 addresses the relationship between professional learning and knowledge management. In Sect. 3, we briefly discuss the LaaN theory as a theoretical basis for our work. Section 4 presents the conceptual and implementation details of the PRiME project. Finally, Sect. 5 gives a summary of the main results of the paper and outlines perspectives for future work.

2 KM and TEL

In a company context, Knowledge Management (KM) and Technology-Enhanced Learning (TEL) have so far been regarded as two impartial areas. While KM concentrates on knowledge creation and distribution, TEL focuses on formal learning and training of the employees. This tightened perspective can still be read from todays companies structures. KM and TEL are commonly related to two different departments, namely IT and human resources.

2.1 KM

With the emergence of KM in the 1990s, organizations had highest hopes in it to improve the knowledge worker performance and at the same time increase the efficiency of the organization to achieve strategic advantages. In the KM literature, there have been two major views on knowledge, namely knowledge-as-a-thing and knowledge-as-a-process [1,2].

The idea of knowledge-as-a-thing assumes KM to be most likely simple information management [3–6]. In general, it covers information capturing, storing, and reusing. Capturing knowledge, however, is not an easy task and moreover very time and effort consuming. The management of knowledge also conflicts with the work process and describes an additional overload. Furthermore, the knowledge-as-a-thing KM models cannot deal with the complex nature of knowledge including e.g. knowledge evolution or its context-sensitivity.

The more recent KM initiatives stress the importance of the peoples side of KM and view knowledge as a process. These initiatives often address the duality of knowledge and move the focus to the distinction and conversion between tacit and explicit knowledge. A popular representative of the class of knowledge-as-a-process KM models is Nonaka and Takeuchis SECI model, which describes knowledge as a spiraling process of socialization, externalization, combination, and internalization which are transforming knowledge between tacit and explicit forms [7]. Due to the variable iterations of the four steps, the model creates the impression to be flexible. However, it is as predetermined as all the knowledge-as-a-process KM models trying to describe an automated process for knowledge creation not able to deal with complexity of knowledge and the unpredictable nature of the KM process.

In response, in recent years, the importance of personal knowledge has been highlighted in various works and the interest in the topic of personal knowledge management (PKM) has steadily increased [8–10]. PKM recognizes that knowledge as well as learning is personal in nature. It puts the knowledge worker and her tacit knowledge at the center. In contrast to the early KM approaches, the PKM approach shows a bottom-up instead of top-down flow of knowledge. However, the current PKM approaches are still very process-oriented and do not really deal with the relation between personal and organizational KM. So far, there are no underlying, supporting theoretical frameworks for PKM and problems like rapidly changing knowledge with a very short half-life, the complexity of work and its environments, etc. are not considered [1].

2.2 TEL

TEL actually shares the same fate with KM. Summarizing different available approaches, TEL commonly means offering Virtual Learning Environments (VLE). These include Learning Management Systems, Learning Content Management Systems, Content Management Systems, and Course Management Systems. All of them concentrate on the provision of information. Although efforts have been made in regard to interoperability of such information repositories, they are still centralized and commonly under the control of a formal educational institution [11].

In the last years, TEL has been influenced by the emergence of the Web 2.0 movement. The term TEL 2.0 emerged to refer to TEL approaches that adapt new techniques for collaboration, networking, and learners active participation in the learning process. While that offers great possibilities, TEL did not really change or influence the traditional pedagogical principles behind it. Content is still organized in standard ways, following the top-down approach pushing information to the learners. Gained knowledge is time-limited e.g. semester-bound and not seen as continuous or fluid. By this linear and predefined process, newly gained knowledge cannot be reused and gets lost [12,13].

2.3 Convergence of KM and TEL

Over the past years, companies and researchers are starting to recognize relationships and intersections between the KM and TEL fields and to explore the potential and benefits of their integration [5,14,15]. Chatti et al. [2] go a step further and point out that professional learning and knowledge management can be viewed as two sides of the same coin and stress the need for the seamless integration of the two concepts into one solution for the purpose of increasing individual and organizational performance. The authors introduce the Learning as a Network (LaaN) theory as a bridge between TEL and KM. In the next section, we briefly discuss the LaaN theory as a theoretical basis for our work.

3 The LaaN Theory

The Learning as a Network (LaaN) theory has been proposed by Chatti [16,17] as a new vision of learning towards a new model of personalized and networked learning. LaaN provides the theoretical foundation to address the diverse learning needs of individual learners in todays learning environments characterized by increasing complexity and fast-paced change. LaaN draws together some of the concepts behind connectivism [18], complexity theory [19–21], and double-loop learning [22,23]. An abstract view of LaaN is depicted in Fig. 1.

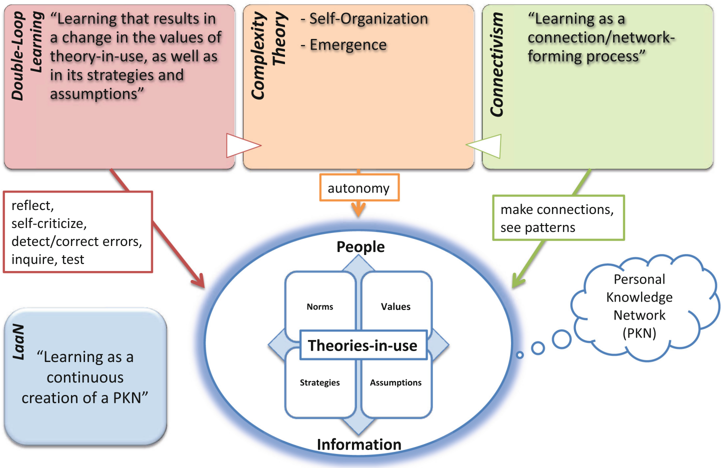

Fig. 1. The LaaN theory [16].

Within LaaN, connectivism, complexity theory, and double-loop learning converge around a learner-centric environment. LaaN starts from the learner and views learning as the continuous creation of a Personal Knowledge Network (PKN). A PKN shapes the knowledge home and the identity of the individual learner. For each learner, a PKN is a unique adaptive repertoire of:

– Tacit and explicit knowledge nodes (i.e., people and information) (external level).
– Ones theories-in-use. This includes norms for individual performance, strategies for achieving values, and assumptions that bind strategies and values together (conceptual/internal level).

In LaaN, the result of learning is a restructuring of ones PKN, that is, an extension of ones external network with new knowledge nodes (external level) and a reframing of ones theories-in-use (conceptual/internal level).

LaaN-based learning implies that a learner needs to be a good knowledge networker as well as a good double-loop learner. The ability to create an own representation of knowledge, reflect, (self-) criticize and finally change and correct it is as important as the capability to recognize patterns or find, aggregate, and remix available knowledge nodes.

At the heart of LaaN lie knowledge ecologies. A knowledge ecology is based on the concept of PKNs, loosely joined, and can be defined as a complex, knowledge intensive landscape that emerges from the bottom-up connection of PKNs. Knowledge ecologies house self-directed learning that occurs in a bottom-up and emergent manner, rather than learning that functions within a structured context of an overarching framework, shaped by command and control. As compared to popular social forms that have been introduced in the CSCL and CSCW literature such as communities of practice, knots, coalitions, and intensional networks, knowledge ecologies are more open, more flexible, less predictable, and less controlled [2].

LaaN further represents a vision of professional learning, where the line between KM and TEL disappears. Unlike traditional KM and TEL perspectives, LaaN views knowledge as a personal network rather than as a thing or process. In LaaN, work/learning is viewed from a professional learner perspective, and KM and TEL are seen as being primarily concerned with a continuous creation of a PKN. This ensures that the differences between KM and TEL are converging around a learner-centric work/learning environment and manage that the roles of KM and TEL are blurring into one, namely supporting professional learners in continuously creating and optimizing their PKNs. In this sense, KM and TEL are not the two ends of a continuum but the two sides of the same coin. Moreover, LaaN enables the seamless integration of learning and work. The view of learning as the continuous creation of a PKN makes learning and work so intertwined that learning becomes work and work becomes learning. As illustrated in Fig. 2, professional learning in LaaN is no longer regarded as an external online training activity separate from the work flow, but rather as a learner-controlled evolving activity embedded directly into work processes [2].

In the next section, we present the details of the PRiME project as a possible application of the LaaN theory.

4 PRiME

The joint research project Professional Reflective Mobile Personal Learning Environments (PRiME) is conducted by the Learning Technologies Research Group

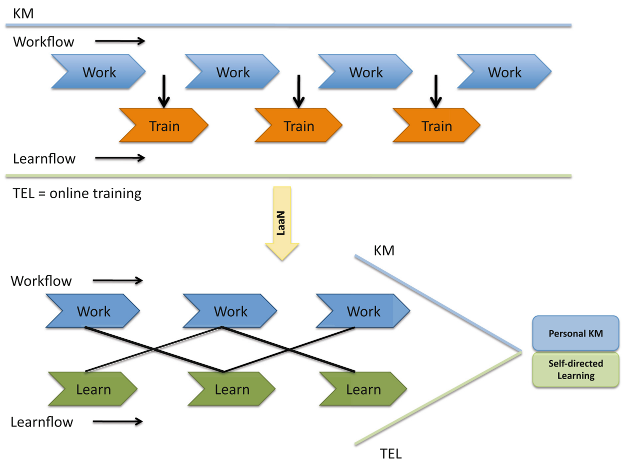

Fig. 2. LaaN: Convergence of KM and TEL [2].

of the RWTH Aachen University and DB Training, Learning & Consulting of the Deutsche Bahn AG. It is funded by the German Federal Ministry of Education and Research with a runtime of three years, finishing in June 2016 [24].

PRiME illustrates the LaaN theory in action. It offers an integrated professional learning and knowledge management framework for personal as well as organizational learning, addressing the following objectives:

- Provide an innovative professional learning approach, where informal and network learning converge around a self-directed learning environment.
- Design a work-integrated framework that links mobile job activities and self-directed learning in context.
- Develop and evaluate mobile learning applications to support mobile learning in context.
- Support continuous knowledge networking and reflection at three levels: (a) the personal learning environment (PLE) level where professional learners can annotate learning materials on their mobile tablet devices; (b) these materials can be shared, commented, and rated by peers at the personal knowledge network (PKN) level; (c) the newly generated learning materials can then be shared and used within the company at the network of practice (NoP) level.
- Develop and evaluate learning analytics tools and methods (e.g. dashboards, recommendation, intelligent feedback, context-based search) to support reflective learning at the workplace.

In the next sections, we discuss the underlying concepts and the current implementation results of the PRiME project.

4.1 Conceptual Approach

The main goal of PRiME is to offer seamless learning across time, location, and social contexts combining the work and learning processes into one. Context has been identified as a key factor in workplace learning to achieve effective learning activities. Nowadays, professional learners perform in highly complex knowledge environments. They have to deal with a wide range of activities they have to manage every day. Moreover, they have to combine learning activities and their private and professional daily life. The challenge here is thus how to support learning activities across different contexts [24,25].

PRiME translates the principles of LaaN into actual practice. In PRiME, a professional learner is a lifelong learner who is continuously creating and optimizing her network. Driven by LaaN principles, PRiME aims at helping professional learners to continuously build their personal networks in an effective and efficient way, by providing a freeform and emergent environment conducive to networking, inquiry, and trial-and-error; that is an open environment in which learners can make connections, see patterns, reflect, (self)-criticize, detect and correct errors, inquire, test, challenge and eventually change their knowledge; thus changing the organizational knowledge.

The learning process in PRiME is a spiral and cyclic conversion of individual and organizational knowledge at three different layers of knowledge networking and maturity: the personal learning environment (PLE), the personal knowledge network (PKN), and the network of practice (NoP), as depicted in Fig. 3.

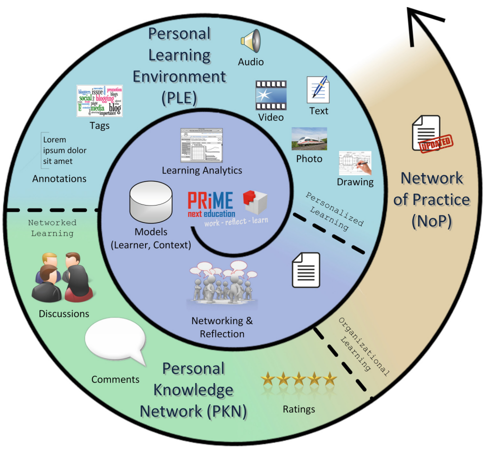

Fig. 3. Continuous Knowledge Networking in PRiME.

4.2 Scenarios

PRiME can be used in any organizational setting. Mobile professional learners represent the primary target group of PRiME. As a proof of concept, we addressed in this work service technicians at Deutsche Bahn as a possible target group. These include car inspectors, specialist authors, training developers, and trainers working in the field of car inspection service. In the following sections, the different possible scenarios are explained in some detail.

Car Inspector. The car inspector is a mechanic that performs rail-worthiness checks on trains. He repairs small-scale damages on trains and decides about trains' dispositions on extensive problems. The following use case describes a possible flow of workflow of a car inspector with PRiME support.

Carl, being part of the car inspection service team, is using the PRiME system. He has access to the learning materials (called bundles in PRiME) from a workshop he attended recently. The bundles are covering knowledge assets regarding his field of application that has been created by a training developer. Furthermore, Carl searches the system for some bundles that might be useful for his next working day when he will need to deal with a specific machine. He finds several matching bundles that he subscribes to in order to receive changes and news related to these bundles. Carl faces a problem while he is on the field to repair a machine. He checks the related bundles as they are also available offline on his tablet. He finds a small learning unit (called snippet in PRiME) that might assist him with his current problem and follows the instructions provided in the snippet. While repairing the machine, Carl comes up with a new solution. He uses the video camera of his tablet to record the process. He then extends the related snippet with the captured video as annotation and saves it for future use. Whenever he is using the snippet again he gets his annotation associated with it. Back in his office, Carl enhances his annotation with some more information explaining the steps of his new solution in more details. He then shares his annotation with his colleagues who also subscribed to the same bundle. They are informed about the new annotation via a personalized aggregation interface (called Newsstream in PRiME). Carl's contribution further initiates a discussion and his colleagues start to post comments and other annotations related to the same snippet. Some colleagues consider Carl's annotation to be very helpful and give it a very good rating. Carl himself is also informed about those activities in his Newsstream and he is glad that he could help his colleagues. Some weeks later the specialist author who published the snippet became aware of Carl's highly rated solution and asks him for his permission to implement it in a new version of the snippet. All the bundles which contain the enhanced snippet will be updated. The updated bundles are then communicated to all subscribers through their Newsstreams. Carl's contribution is now part of the organization-wide learning materials.

Specialist Author. The specialist author is responsible for the creation of new learning resources. Doris is a specialist author. She creates guidelines, instruction rules related to car inspections. She uses the PRiME Snippet Creator as an authoring tool to easily create multimedia (text, image, audio, or video) learning units. These snippets then be stored in the PRiME system and can be used by training developers as backbones for trainings and workshops (refer to the training developer scenario). Moreover, Doris uses the PRiME Snippeter to automatically convert an existing Word document containing working instructions to a set of snippets.

Training Developer. The training developers are responsible for the selection, aggregation, and creation of trainings from existing learning materials (bundles) created by specialist authors. Corinna is a training developer. She uses the PRiME system to create bundles that may be used in workshops or trainings. She got the task to prepare new bundles to be used by a trainer in a workshop with car inspectors. Corinna uses a PRiME authoring tool (Bundler) to search, filter, and aggregate existing bundles and snippets to create a new bundle. She also reuses parts of bundles she created in a previous work. The PRiME Bundler enables Corinna to easily structure and arrange content in her new bundle with simple drag and drop actions. When she finishes, the new bundle is published and can be used by the trainer in the workshop and subscribed to by the car inspectors who are interested in it. Corinna is informed as soon as someone rates or comments on her bundle. She also receives feedback from the trainer who used her bundle in his workshop. Based on the feedback, she enhances her bundle with further content, rearranges some parts, and deletes content which is not required. Changes of her bundles are again communicated to all subscribers.

Trainer. The trainers are responsible for the organization and execution of the professional technical trainings and workshops with car inspectors. They use the learning materials (bundles) prepared by training developers. These trainings are commonly done in traditional face to face classroom settings, often lasting for several days. During that time, participants interrupt their normal work to attend the training. Besides knowledge about the topic, the trainer should have the didactical skills required for an effective training. George is a trainer and is in charge of practical trainings and workshops with car inspectors, covering facilities and techniques of car inspection services. He is asked to arrange a workshop soon addressing the topic maintenance of passenger trains. Therefore, he makes use of the PRiME system to select relevant bundles required for his workshop. The bundles contain different snippets as textual instructions, diagrams, and demonstration videos. With the help of the PRiME export function, George is able to export the bundles as a simple presentation slides. In the workshop, he collects feedback to the bundles and forwards them to the training developer. After the workshop, the car inspectors get access to the bundles and can subscribe to them for continuous learning, as presented in the car inspector scenario.

4.3 Implementation

PRiME provides an integrated learning and work platform through a set of Web and mobile applications to support continuous knowledge networking at the three different layers.

The document base in the PRiME platform consists of existing company documents, such as guidelines and instruction rules. The majority of such documents are already available in a digital form, e.g. as Word, PowerPoint or PDF. Through a Web-based application, called the *Bundler* (see Fig. 4), these documents are imported into the PRiME system, processed according to their hierarchical logical structure, and stored in a tree-like structure. Specialist authors

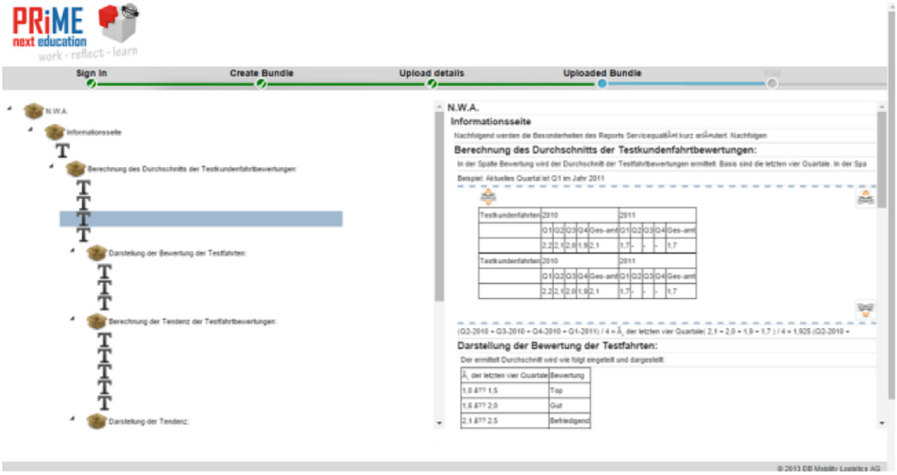

Fig. 4. Bundler: Existing documents are imported and processed in the PRiME system.

can use the *Bundler* to upload their documents, which can be automatically processed to fit the PRiME data schema which consists of so-called *Snippets* and *Bundles*. Snippets represent atomic learning units that can take the form of text, table, image, audio, or video. Bundles are used to structure such snippets. Each bundle can hold several snippets and also several sub-bundles. The bundles can be seen as the structure of sections in a book, whereas the snippets are the content of a book. Whenever possible, additional information, such as the name of the author, keywords, or other metadata, is also extracted from the uploaded document. After this initial step, the document is presented in its tree-like structure of bundles and snippets to the specialist author who can manually alter the automatically generated result by splitting and merging single elements. When the author is satisfied with the result, the initial version of this document is released to the PRiME system as a set of bundles and snippets which can be used by car inspectors as learning resources and reused by training developers and trainers as building blocks for training and workshop materials.

The *Bundler* can further be used by training developers to mash up and create own bundles from existing bundles and snippets in the PRiME system according to their needs (see Fig. 4). Thereby, the training developers can search for already existing snippets. Different filters and search criteria help to limit the search results to only show context-relevant snippets. In the left column of the screenshot, a tree-like view helps to easily structure and arrange snippets at various levels of a new bundle with simple drag and drop actions. The right column shows a document-like view of the aggregated bundle. The new bundle is then published and can be used by trainers in their workshops and subscribed to by the car inspectors who are interested in it. The *Bundler* further offers different export modules that allow the trainer to convert bundles to traditional formats, such as pdf, word, PowerPoint that can be used as handouts in the workshop.

In addition to converting an existing document to snippets, and mixing up existing snippets to new bundles, the specialist author may also use the *Bundler* application to create snippets and bundles from scratch.

In PRiME, learning is a continuous process which involves the learners, their personal networks, and the organization itself. PRiME divides the learning and working process into three layers, namely the Personal Learning Environment (PLE), the Personal Knowledge Network (PKN), and the Network of Practice (NoP). In the following sections, we discuss in detail the work and learning activities in relation to each layer and how these activities are supported by the PRiME tool set.

Personal Learning Environment (PLE). The Personal Learning Environment (PLE) represents the knowledge home of professional learners. A PLE enables professional learners to create their individual learning environments by compiling their own individual knowledge assets which are relevant for their everyday working context. Each learner decides on her own, which information is important for solving daily tasks and for improving ones knowledge. The task of a mobile PLE is to support the learners in their everyday life, either for solving current tasks and problems or for learning in context. Knowledge assets in the PRiME system include bundles, snippets, and annotations. An annotation is multimedia information created by the learner, which can either be attached to bundles and snippets or detached from those structures.

In a PLE, a learner should not only be able to define which information is available but also how the learning environment should look like. One possibility to achieve this is to implement one monolithic application with all the required functionalities and various options for the learner to adjust everything. In the PRiME system, we opted for a set of applications where each application is responsible for a single task. All PRiME applications are able to communicate with each other and to share functionalities. By selecting the own set of applications, the learner also decides how the own learning environment looks like. The starting point for all the PRiME applications on the learners mobile device is the Dashboard (see Fig. 5). It encapsulates all the functionalities by displaying each PRiME application and by providing a centralized communication system for all the installed applications in the PRiME ecosystem.

With the help of the application *BundleReader* (see Fig. 6), a car inspector is able to subscribe to, create, and display her own set of bundles and snippets that are required for her work. Alongside, she can also create her own multimedia annotation for each bundle or snippet available in the application. For displaying additional information for one bundle or snippet, the user has to swipe a bar from the right border to the center. This newly opened area contains all the metadata about the currently highlighted bundle or snippet, namely the author, the version, the date of last change, as well as public annotations and comments. Annotations are questions and corrections to a bundle or snippet that offer the possibility to capture knowledge during the work process. Instead of taking a note on a loose sheet of paper which normally gets lost, car inspectors can take a photo of a machine or

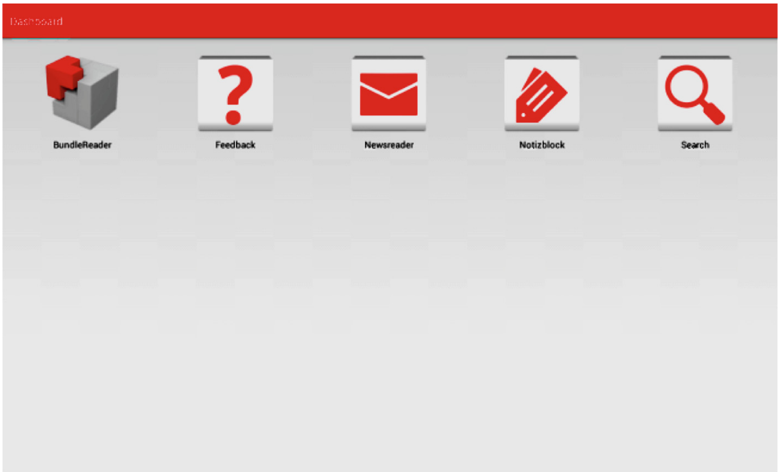

Fig. 5. The Dashboard is the main entry point to the PRiME ecosystem.

record a short video of a procedure. In general, annotations cover various types of multimedia (e.g. text, image, audio, video, or drawing) which can be created very easy and they provide a great expressiveness at the same time. To create a new personal annotation, a user can just tap the toolbox in the upper right corner and select the type of annotation to be added. The newly created annotation will appear on the right side of the application, associated with the bundle or snippet it has been created for. Annotations are context-sensitive and can be extended automatically with meta-information, such as recording time or location. At first, they are strictly personal and not visible to any other user. Thus, they can hold some personal work instructions that are helpful for future tasks. Furthermore, the car inspector can use the intelligent search functionality provided by the BundleReader to discover context-relevant bundles. For example, some knowledge is location-based due to machinery, or physical conditions such as noise might result in exclusion of media types containing audio. The search result can further be filtered according to author, topic, keywords, time, location, etc.

Car inspectors at work often do not have the time to write extensive annotations and link them to a specific bundle or snippet. The application Notepad was developed to support car inspectors in taking quick notes in form of text, picture, video, audio, or drawing which can be used for self-reflection after work or as basis for annotations on bundles and snippets in the *BundleReader*. For example, while reading a snippet, the car inspector might remember that she took a picture which can clarify the instructions given in the snippet and use the picture as annotation for that snippet.

Figure 7 shows the *Notepad* application. A new note can easily be created by tapping the red button in the lower right side of the application. A new menu appears where the car inspector can select which kind of note she wants to create. In addition to the note itself, keywords, short comments and other meta

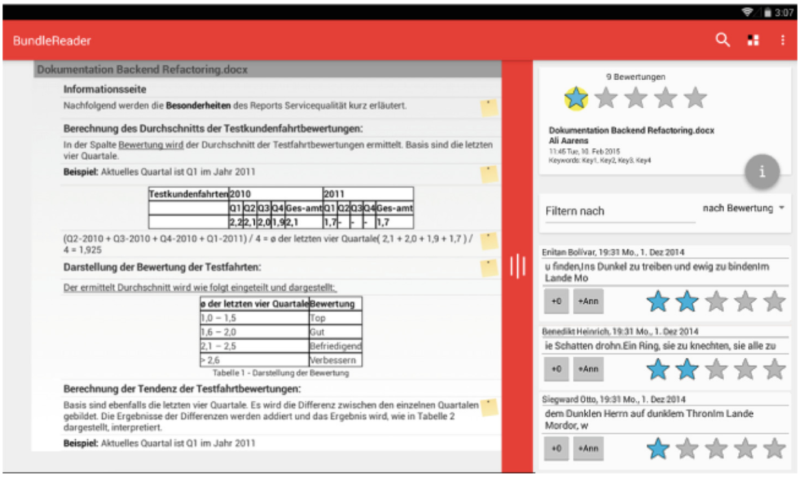

Fig. 6. The BundleReader enables learners to subscribe to, display and annotate bundles and snippets.

information, such as time and location can be added optionally. This simplifies the process of finding the correct note when needed. Selection from storage like SD card is possible as well as using the device-internal tools to record multimedia like the camera application. A personal media gallery collects all the created notes. The car inspector can define when to synchronize them with a server-side personal repository.

Personal Knowledge Network (PKN). The Personal Knowledge Network (PKN) represents the networking layer in PRiME. The PKN layer fosters continuous networking and collaborative knowledge creation. It enables professional learners to share tips and tricks and collaboratively work on the constant improvement of the available knowledge assets.

As mentioned in the previous section, at the PLE layer, a car inspector can use the *BundleReader* to make annotations on the bundles and snippets she has subscribed to and keep them private per default. If she decides that her personal annotations are worth sharing, she can publish them to all other subscribers or share them with selected peers or groups that can be personally defined. Annotations can then be seen by all recipients who can give ratings and might reply to these annotations with their own ones. This way, expert discussions can emerge resulting in collaborative creation and maturing of knowledge. Car inspectors who apply the knowledge in their daily tasks have thus the possibility to give valuable feedback to aid the specialist authors in improving the produced bundles and snippets.

As the available knowledge is rapidly growing and updates in the system are hard to track, PRiME users should have an easy way to stay up to date without being overwhelmed with the constant flow of information. This is achieved

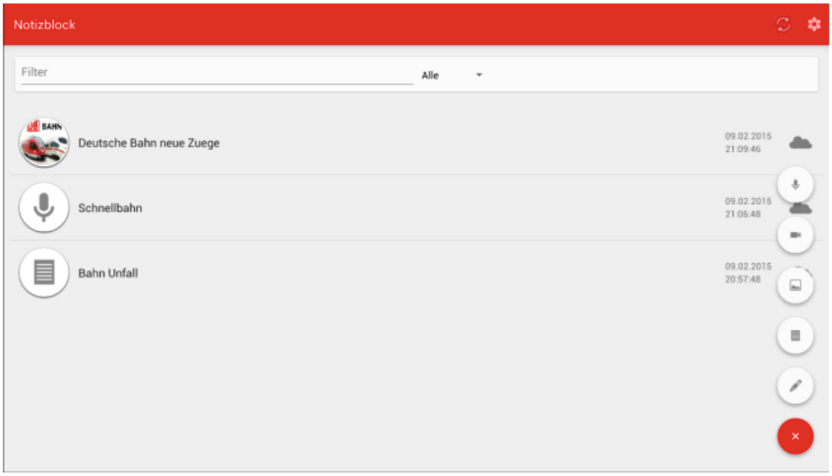

Fig. 7. The Notepad enables learners to quickly take notes in their PLE.

through the native mobile application *Newsstream* which provides an aggregated view of recent activities in the PRiME system, as shown in Fig. 8. Car inspectors, specialist authors, training developers, and trainers who subscribed to a specific bundle continuously receive notifications on the annotations, ratings, and changes made to the bundle. By clicking on a notification, they are directly forwarded to the respective bundle, snippet, or annotation in the *BundleReader*. Car inspectors can follow the discussion and rating activities on the bundle or snippet they are interested in and discover quality annotations contributed by peers. They can also set filters so that e.g. only notifications related to a specific snippet or given by a specific peer are displayed. Furthermore, they can use the *Newsstream* to receive recommendations according to their preferences and activities in the system. On the other hand, specialist authors, training developers, and trainers can get continuous feedback that can be used in the enhancement of their snippets and bundles.

Network of Practice (NoP). The Network of Practice (NoP) represents the organization layer in PRiME. It supports the propagation of the knowledge created at the PLE and PKN layers to the entire organization. The NoP layer harnesses the collective intelligence to ensure that the organizational knowledge is accurate and up to date. An organization represents a knowledge ecology. Organizational learning occurs when individuals within an organization experience a problem and work on solving this problem. This happens through a continuous process of organizational inquiry, where everyone in the organizational environment can inquire, test, compare and adjust her knowledge, which is a private image of the organizational knowledge. Effective organizational inquiry then leads to an update of ones knowledge, thereby updating the organizational knowledge.

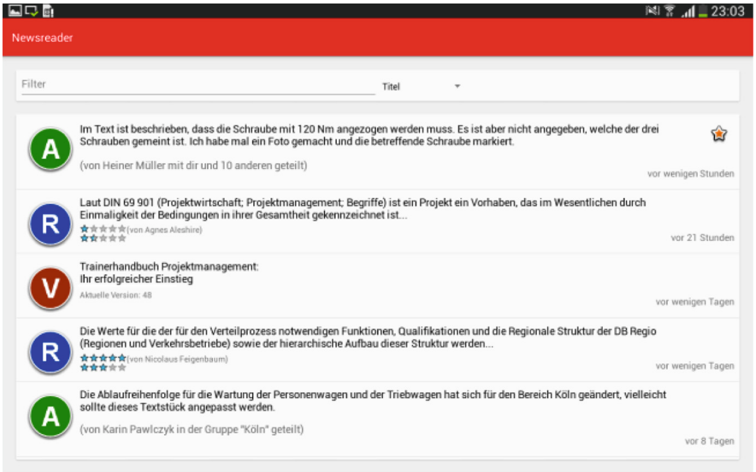

Fig. 8. The Newsreader provides an aggregated view of recent activities.

The knowledge which is available in PRiME can be continuously improved with every action in the system. At the PKN layer, the collective intelligence decides which knowledge is of high quality through commenting and rating. Quality knowledge that emerges as a result of the continuous interaction between PRiME users at the PKN layer builds the cornerstone for the enhancement of the organization-wide knowledge assets. When a new annotation to a snippet at the PKN layer is highly rated, the specialist author is notified and can use this annotation for the enhancement of the snippet. Training developers and trainers can use the improved snippet in their trainings and workshops. Car inspectors who subscribed to this snippet will automatically get notified about this update. The whole process starts then anew at the PLE layer. This continuous knowledge networking process ensures an effective individual and organizational learning.

5 Conclusion and Future Work

In this paper, we addressed the challenge of seamless integration of Knowledge Management (KM) and Technology Enhanced Learning (TEL). Driven by the Learning as a Network (LaaN) theory, which presents a bridge between TEL and KM, we discussed the theoretical, conceptual, and implementation details of the Professional Reflective Mobile Personal Learning Environments (PRiME) project. PRiME fosters knowledge in action and realizes a seamless professional learning framework which connects learning and work processes. Learning in PRiME is the result of continuous knowledge networking at three layers, namely personal learning environment (PLE), personal knowledge network (PKN), and network of practice (NoP). Different mobile applications have been introduced to support the various activities related to each of these layers.

Future work will include an empirical study of our approach, which will allow us to thoroughly evaluate the usability of the developed applications as well as the effectiveness of our method to support work-integrated networked learning. Besides extending the PRiME application ecosystem, we also plan to leverage different learning analytics methods to support self-reflection, awareness, recommendation, and intelligent feedback in professional networked learning environments.

References

1. Chatti, M.A.: Knowledge management: a personal knowledge network perspective. J. Knowl. Manag. **16**(5), 829–844 (2012)
2. Chatti, M.A., Schroeder, U., Jarke, M.: LaaN: convergence of knowledge management and technology-enhanced learning. IEEE Trans. Learn. Technol. **5**(2), 177–189 (2012)
3. Hildreth, P., Kimble, C.: The duality of knowledge. Inf. Res. **8**(1), 142 (2002)
4. Kimble, C., Hildreth, P., Wright, P.: Communities of practice: going virtual. In: Knowledge Management and Business Model Innovation, pp. 220–234. Idea Group Publishing, Hershey (USA) (2001)
5. Malhotra, Y.: Integrating knowledge management technologies in organizational business processes: getting real time enterprises to deliver real business performance. J. Knowl. Manage. **9**(1), 7–28 (2005)
6. Wilson, T.: The nonsense of knowledge management revisited. Inf. Res. **8**(1), 1–8 (2002)
7. Nonaka, I., Takeuchi, H.: The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation. Oxford University, New York (1995)
8. Gorman, G.E., Pauleen, D.J.: The nature and value of personal knowledge management. In: Personal Knowledge Management: Individual, Organizational and Social Perspectives, pp. 1–16. Gower Publishing Limited, Farnham Surrey (2011)
9. Prusak, L., Cranefield, J.: Managing your own knowledge: a personal perspective. In: Pauleen, D., Gorman, G. (eds.) Personal Knowledge Management: Individual, Organizationaland Social Perspectives, pp. 99–114. Gower Publishing Ltd., UK (2011)
10. Snowden, D., Pauleen, D., van Vuuren, S.: Knowledge management and the individual: its nothing personal. In: Pauleen, D., Gorman, G. (eds.) Personal Knowledge Management: Individual, Organizational and Social Perspectives, pp. 115–128. Gower Publishing Ltd., UK (2011)
11. Downes, S.: E-learning 2.0. ACM eLearn Magazine (2005)
12. Brown, J.S., Adler, R.P.: Minds on fire: open education, the long tail, and learning 2.0. EDUCAUSE Rev. **43**(1), 16–32 (2008)
13. Mott, J., Wiley, D.: Open for learning: the CMS and the open learning network. Education **15**(2), 4–5 (2009)
14. Grace, A., Butler, T.: Learning management systems: a new beginning in the management of learning and knowledge. Int. J. Knowl. Learn. **1**(1–2), 12–24 (2005)
15. Lytras, M., Naeve, A., Pouloudi, A.: Knowledge management as a reference theory for e-learning: a conceptual and technological perspective. Int. J. Distance Educ. Technol. **3**(2), 1–12 (2005)
16. Chatti, M.A.: Personalization in technology enhanced learning: a social software perspective. Ph.D thesis, RWTH Aachen University (2010)

17. Chatti, M.A.: The LaaN theory. Personalization in Technology Enhanced Learning: A Social Software Perspective. Shaker Verlag, Aachen (2010)
18. Siemens, G.: Connectivism: a learning theory for the digital age. Int. J. Instructional Technol. Distance Learn. 2(1) (2005)
19. Holland, J.H.: Complex adaptive systems. Daedalus **121**(1), 17–30 (1992)
20. Holland, J.H.: Emergence: From Chaos to Order. Addison-Wesley, Reading (1998)
21. Snowden, D.: Complex acts of knowing: paradox and descriptive self-awareness. J. Knowl. Manag. **6**(2), 100–111 (2002)
22. Argyris, C., Schön, D.A.: Organizational Learning, A Theory of Action Perspective. Addison-Wesley, Reading (1978)
23. Argyris, C., Schön, D.A.: Organizational Learning II: Theory, Method and Practice. Addison-Wesley, Reading (1996)
24. Greven, C., Chatti, M.A., Thüs, H., Schroeder, U.: Context-aware mobile professional learning in PRiME. In: Kalz, M., Bayyurt, Y., Specht, M. (eds.) mLearn 2014. CCIS, vol. 479, pp. 287–299. Springer, Heidelberg (2014)
25. Thüs, H., Chatti, M.A., Yalcin, E., Pallasch, C., Kyryliuk, B., Mageramov, T., Schroeder, U.: Mobile learning in context. Int. J. Technol. Enhanced Learn. **4**(5–6), 332–344 (2012)

Learners' Cultures in the Context of Education

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Abstract. Job-related migration has been fostered across Europe balancing unemployment in one country with demands for employees in others. However, the numbers of early school leavers and university dropouts significantly increased in the hosting countries. We propose a higher measure of cultural sensitivity in education in order to prevent frustration. The Learning Culture Survey investigates learners' expectations towards and perceptions of education on international level with the aim to make culture in the context of education better understandable. After a brief introduction, we subsume the steps taken during the past seven years and found results. Subsequently, we introduce a method for the determination of conflict potential, which bases on the understanding of culture as the level to which people within a society accept deviations from the usual. We close with demonstrating the usefulness of the data and insights from our Learning Culture Survey in the context of practical scenarios.

Keywords: Culture-sensible education · Educational culture · Culture-related conflicts in education · Learning culture survey

1 Introduction

With the increasing internationalization of classrooms and the distribution of e-Learning programs and content through the Internet, a better understanding of the role of culture in education gets indispensible. Reports of increasing numbers of early school leavers and dropouts in universities accumulate; mainly learners with migration background are concerned [1]. It is not in the responsibility of the learners to adapt the given conditions of their learning context, but the educational institutions' duty to ensure that an environment is provided which leads to productive learning for any kind and type of learner [2]. Even established e-Learning providers rather waive the chance to attract a higher number of learners and stick to their local markets, instead of risking unsatisfied learners because of unforeseen cultural conflicts [3]. Meanwhile, in support of finding solutions, the EC defined a related key issue for funding in the context of the 2015-call for project proposals.

In his study, Nilsen [4] found that the main reasons for students dropping out were ineffective study strategies, a mismatch between expectations and content in the study program, and a lack of motivation. Bowman [5] even claims that strong efforts should be made in order not to 'destroy' the initial motivation by confronting the learners with unnecessary conflicts. So far, we know that besides language gaps and content-related

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issues, the learners' motivation is threatened by unmet expectations and not understandable regulations, arising from culture-specific differences between their origin and the new context.

In e-Learning scenarios, a constantly high level of motivation is the most crucial success factor [3]. If learners lose their motivation in a face-to-face scenario, the educator still has a chance to recognize that and can support the regain of motivation [6]. In e-Learning scenarios, this chance rarely is given; without recognizing the learners' mimics and gestures as tools to communicate frustration [7], the instructors depend on explicit communication, which often does not happen due to cultural reasons.

The Learning Culture Survey investigates learners' perceptions in different national and regional contexts and aims to support educators to better understand educational culture in general and cultural differences between specific educational contexts, in particular. Such an understanding is relevant for the development of culture-sensitive education. We further on aim to support both learners and educators in their preparation efforts when planning to study or teach in other countries.

2 The Learning Culture Survey (LCS)

In the following we distinguish between "culture in education", which is used as a general term, without a direct relation to a particular context, "educational culture", which is used when a specific context is referred to and "learning culture", which is related to perceptions of and attitudes towards education from the perspective of the learners.

Today's applied comparative culture research mostly refers to culture as persistent value-driven perceptions and attitudes, which, amongst all people within national societies are homogenously favored or refused (e.g. literature reviews from [8, 9]). Geert Hofstede [10], as a pioneer [11] and still, one of the central proponents of this "etic" concept for culture research, speaks of culture as the "Software of the Mind" which goes back to Montesquieu's "spirit of a nation" (18th century). In his research, Hofstede initially found four cultural dimensions (later on, two more dimensions followed), which focused on basic values and classified around 40 nations through specific key values per dimension. Following Hofstede's demonstrated examples [12], it is possible to predict and compare the relative cultural distance between two nations according to concrete attitudes and perceptions that are related to each of the dimensions. In other words, according to the results, people from one nation are considered more likely to act or react in a certain way than those of another nation. Köppel [13] suggests that one reason for the persistent high level of popularity of this approach lies in its' simplicity. Alongside its achieved prominence, Hofstede's Dimensions Model has constantly been challenged and criticized on methodological, interpretational, and ethical levels (e.g., [8, 9, 14, 15]).

Several further reasons than the already found points of criticism affirmed our own doubts if the national values from Hofstedes' dimensions model and the concept of a general national culture would appropriately reflect culture in education. For the context of culture in education, we initially decided to adopt the majority-based and group-related culture definition of Oetting [16], who suggests using the term ‘to describe the customs, beliefs, social structure, and activities of any group of people who share a common identification and who would label themselves as members of that group’. We could not imagine that basic values exclusively should be responsible for educational culture. According to our own practical experiences from the fields of school education, Higher Education, and professional training, we saw significant differences between their modi operandi, which did not necessarily reflect basic values or national cultures at all.

Another reason for doubts regarding the applicability of Hofstede’s dimensions model in the context of educational culture resulted from the reported experiences from Mitra et al. [17] which later on were confirmed by Buehler et al. [18]: Both research groups found that the children in their studies below an age of twelve years acted quite differently from older children as they rather followed their curiosity than the assumed cultural biasing. Last, we were unsure if the culture within educational institutions actually stays persistent over time after changes regarding basic conditions took place.

2.1 LCS: Operationalization

Besides a cross-disciplinary literature review on reported conflicts in education and culture research in general, we conducted qualitative pre-studies involving university students and educators. In the conducted (informal) interviews, we asked them for perceived cultural conflicts during their times of studying abroad and related to other (foreign) students within the home university. The first version of our questionnaire considered both the reported conflicts in education from the literature and issues that arose from the interviews.

The questionnaire was designed for the context of Higher Education and originally consisted of 128 items related to the following aspects of education [19]:

- Role, responsibilities, and tasks of lecturers
- Feedback
- Motivation
- Gender issues
- Several aspects of group work
- Time management
- Role, responsibilities, and tasks of tutors
- Demographic data

The full questionnaire has been published in its English language version [20].

In 2009, we decided to start with our investigation within the only two national contexts, which Müller et al. [21] found to having more or less culturally homogenous populations, i.e., Germany and South Korea. These two national contexts conveniently also appeared perfectly suitable for the initial study because of their generally very different educational systems and traditions.

Before the implementation took place, the questionnaire was translated to German and Korean. Several test studies and refinement cycles were applied in both contexts in order to ensure its’ comprehensibility and appropriateness. Regarding socially sensible topics, we had to expect that the students would rather provide socially acceptable answers than expressing their actual opinions; even though the respondents were considered to stay anonymous. Thus, we removed related items and reformulated others. In the end, 102 items remained for the initialization of the field study.

For most of the items, we applied a 4-point Likert Scale. We wanted to force the respondents to take a position instead of giving them the chance to choose a neutral response option [22]. Our aim was to design a standardized questionnaire, reusable in later steps within any context in the same form (just translated to local languages). For future contexts, we had to expect that items might not apply in the same measure as experienced in the test studies. Thus, we provided an additional answer-option, which was "not applicable in my context". We visually separated this option from the main scale in order to avoid that respondents misinterpret it as an integral part of the general answer options. The strategy of separated positioning worked out well: In later studies, this option rarely was used.

2.2 Evaluation and Interpretation

As only criterion for the evaluation, we decided to exclusively accept fully completed questionnaires including both the items that had to be evaluated and (most of) the demographic data.

From our investigated contexts, we received very different sample sizes, which, in the original design of the scale, would not have been comparable amongst each other because of the extreme values' different impacts on the full samples. In order to solve this problem, we followed the recommendation of Baur [23] and binarized our results for the contrasting across contexts in positive and negative answers. Baur particularly recommends the binarising of ordinal-scaled results in order to produce clearer results and prepare ordinal-scaled data for operations that originally are reserved for interval-scaled data. There is a controversial discussion on applying higher-level statistical methods to ordinal-scaled data [24]. We followed the recommendation of Porst [25] to case-sensitively check the results for appropriateness, which, in our case, revealed inconsistent results when calculating variance, covariance and standard deviation. In contrast, the calculated mean was sound between the 40- and 60-quantiles and thus, usable to provide information on the answer distributions, which else would have been lost after the binarising process. When directly contrasting results across contexts, we focused on the percentage of positive answers.

For the decision if a result regarding a certain item actually reflects culturally motivated or rather individual preferences of the students, we generally assumed that if we find a clear tendency to rejection or acceptance (negative/positive), the answer was culturally motivated, else, individually. As a clear tendency, we defined everything below 40 % positive answers as rejection and everything above 60 % positive answers as acceptance. All items evaluated between 40 % and 60 % positive answers were assumed to be too close to an equal distribution and thus, probably expressing individual preferences. We chose such a large interval as our "fuzzy area" because in our context of learning culture, we had to deal with opinions of people on aspects of life, which at least to a large part were not substantial for the respondents' survival or the general functioning of societies. On individual level, such types of opinions easily could be changed from one to another moment. Moreover, we did not know if our results would reveal persistent over time on the large scale.

We cannot clearly determine if the individual responses of the participants in our study are driven by desires (what they wish to be) or the status quo (what they expect to be due to prior experiences). In retrospective and for most cases, the results are quite clearly showing that the students evaluated according to their experiences.

2.3 Implementation

As for the first wave of our large-scale implementation, we found very different conditions in the contexts of Higher Education in Germany and in South Korea.

With our online questionnaire, we were able to address the entire student populations of the three German universities 'University of Cologne', 'University of Applied Sciences Bonn-Rhein-Sieg', and 'University of Potsdam'. Each university-administration sent the invitation for participation to all of their registered students through their internal E-Mail distribution system. The response rates between 2-6 % for each university were in accordance with the usual experiences for response rates in online questionnaires. In total, from the three universities, 3225 students started answering and 1817 students left fully completed questionnaires. The distribution between female and male students was 544/1268 (five students assigned "other").

In the context of Higher Education in South Korea, we did not have the opportunity to use the online survey within the universities due to legal issues but instead, had to collect the data "on the street", using the paper-based version. In order to still receive something close to random samples, we followed the suggestion of Kromrey [26] and chose our respondents on the basis of a random-route algorithm. More than 50 % of the Korean population lives in and around Seoul. The city has more than 50 universities and a subway system, which links the suburbs and close cities with each other. Thus, we limited our investigation to this city. Due to permanent traffic jam and uncomfortable parking situations, Korean students usually and frequently use the subway. Because of these characteristics, we eventually decided to conduct our survey in the subway and predefined a fixed algorithm where to enter the subway and how to decide which persons were to be invited for participation: Go down the main entrance to the gate, take the first wagon entrance available on your right side and ask all people that appear to have an age between 18 and 30 (starting on your right side and going around in this wagon) if they currently are university students, at least have six further stations to go, and are willed to participate in our survey. After completion of one round, leave the subway on the next stop where another line crosses its way and change the subway line. If possible, follow the direction to the center. In order to involve a high number of subway lines (and thus, catch students on their way to different universities), we started with the only available round-line in the city and randomly changed the initial entry point each day. The condition regarding the six further stations was related to the average time required to complete the questionnaire. Most participants in the German sample (which ended before the Korean study) needed 11–15 min for the completion of the online questionnaire. The subway trains in Seoul take about three minutes from one to another station.

We calculated that 18 min should be enough to introduce how to proceed (no long considerations but intuitive and quick answering), hand out the material, let them complete the questionnaire, and collect the results; in most cases, this calculation worked. For most people, sitting in the subway is boring and so, we achieved a response rate of 50 % (counting just persons claiming to be university students). We had three weeks for the data collection, and received 286 fully completed paper-based questionnaires with a relationship between female and male students of 153/131 (two students selected "other"). 58 of the "delivered" questionnaires had to be rejected because relevant items were left unanswered. The students within the sample studied at 39 universities. From nine universities, we received nine and more completed questionnaires.

The received datasets with many sample elements per university from the German sample were predestined to drive an in-depth analysis by comparing the data not just on university but also on faculty level. The Korean sample, in contrast, was well suitable for a broad analysis on university level.

We were not yet able to determine if the found educational cultures from Higher Education would be transferable to other educational contexts. In the end of 2011, we conducted small-scale studies in five randomly selected enterprises for that purpose: We randomly chose them from the list of stock noted enterprises (DAX), which provide in-house training. Five enterprises eventually granted their participation. However, we were restricted to involve a maximum of 25 participants per enterprise. Apart of defining the condition that the selected employees should work in positions, in which they actually are meant to participate in the provided in-house trainings, we had no further influence on who exactly would be invited; this was an internal decision. As a result, we received seven and more responses just from two of the five enterprises. However, the results from these two enterprises eventually revealed sound because in relevant aspects, they reflected the specific characteristics of the enterprises' organizational cultures' and the age and positions of the participating employees. For this study, we slightly modified the used terminology in our questionnaire. As an example, we changed the term "professor/lecturer" to "instructor".

Between 2012 and 2013, we received further translations of the questionnaire to Bulgarian, Chinese (simplified and traditional), French, Greek, Japanese, Portuguese, Russian, and Turkish. With the support of guest students in Germany, we drove test studies in their home countries, which were Bulgaria (30 sample elements), Ukraine (53), Turkey (40), and British (30) and French (30) Cameroon. These results surely were not representative for each of the countries' contexts of Higher Education but provided first impressions of what we could expect in large-size investigations. In the summer of 2014, we completed another large-size study (online) at the university of Accra in Ghana with 306 fully completed questionnaires (response rate around 3 % and female/male relationship 126/177). In the end of the year, we started the implementation of the LCS online-survey in France. The study in France is on-going since we yet just managed to involve a single university with limited access to the students (so far, we received 75 fully completed responses).

Also in the end of 2014, we were able to repeat our investigation in one of the German universities, namely the University of Applied Sciences Bonn-Rhein-Sieg. The questionnaire, again, was implemented as online survey, and all registered students were invited by the administration using the internal E-Mail distribution system. The investigation served two purposes, first, to find out if the educational culture in this university generally kept persistent over the past years, and second, if the immense logistic and personnel changes that had taken place in the meantime were reflected in the results. The University of Applied Sciences Bonn-Rhein-Sieg still is a quite young and relatively small university. It is constantly expanding on all levels, regarding offered subjects to study, employed professors and staff, and infrastructure. In order to achieve meaningful results with a repetitive investigation, we had to at least wait three years in order to ensure that the prior investigated generation of students (Bachelor and Master) were completely substituted through new students; else, we would have risked receiving data that reflected the memory of students instead of the status quo. In the repetitive study, we received 375 fully completed questionnaires, which is 6, 6 % of the whole student population (5621). The relationship between female and male respondents was 166/208 (one student decided for "other").

3 Findings on Learning and Educational Culture

With our data, we were able to answer most of our beforehand open general questions of educational culture. In the following, the findings are discussed in detail and separated by category.

We use net diagrams for the visualization of the results from two or more contexts. Each diagram is related to a thematic block, like for example "Tasks of the Lecturer". We consider all items within the same thematic block to being directly related amongst each other. In the diagrams, we only display the results according to the found percentage of positive answers. Since the option "Not applicable in my context" has really been used (below 1 %), the rest of the answers can be expected to be rejections.

Please note that displaying the data in this way is meant to facilitate the recognition of differences between contexts, to some extent, eye-candy, but only the crossing points on each of the axes of the diagrams actually represent defined values.

3.1 Learning Culture in Faculties

The German samples were large enough to analyze the data on faculty level. In Fig. 1, we exemplarily display the results of the University of Cologne regarding the thematic block "Tasks of the Lecturer".

On faculty level, we found deviations in the answers of the students regarding all thematic blocks and between each of the faculties within all three universities. The general characteristics of the found patterns were similar across faculties and items. The displayed thematic block "Tasks of the Lecturer" was the one with the highest level of diversity. Regarding this thematic block, the expectations of the students generally were higher in faculties with low numbers of students than in larger faculties.

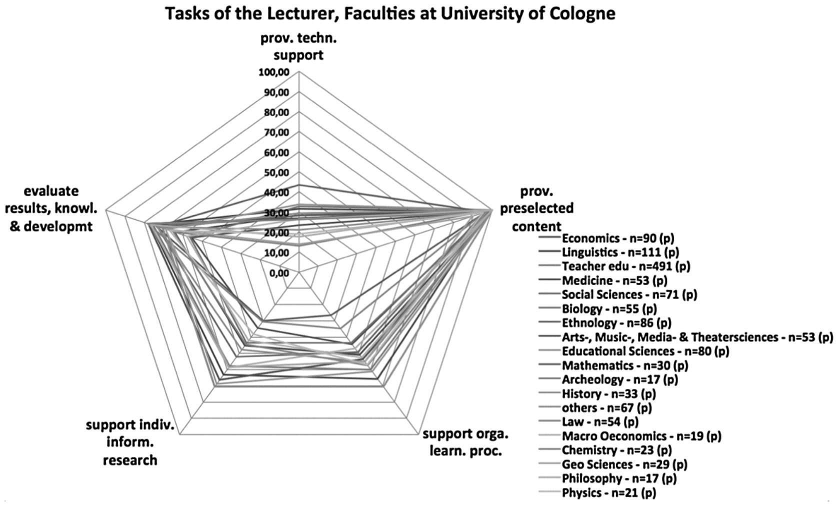

Fig. 1. "Tasks of the Lecturer": Faculties (Cologne).

3.2 Educational Culture in Universities

For the comparison of the educational cultures on university levels, we calculated the positive percentage values over the whole datasets (not about the averages of the faculties) from each of the German universities. Figure 2 displays the results regarding the thematic block "Group work efficiency".

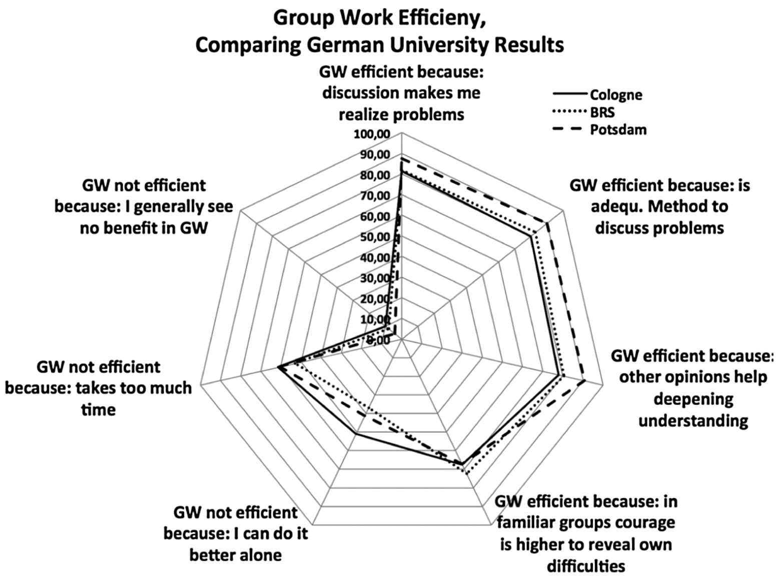

Fig. 2. "Group Work Efficiency": German Universities.

After having built the averages of each university, patterns resulted which were very similar to each other. We yet had to find out if the data of the South Korean sample would lead to a similar effect. Figure 3 displays the results from the thematic block “Group Work – Evaluate Statements”, considering only the South Korean universities, where at least nine sample elements were available.

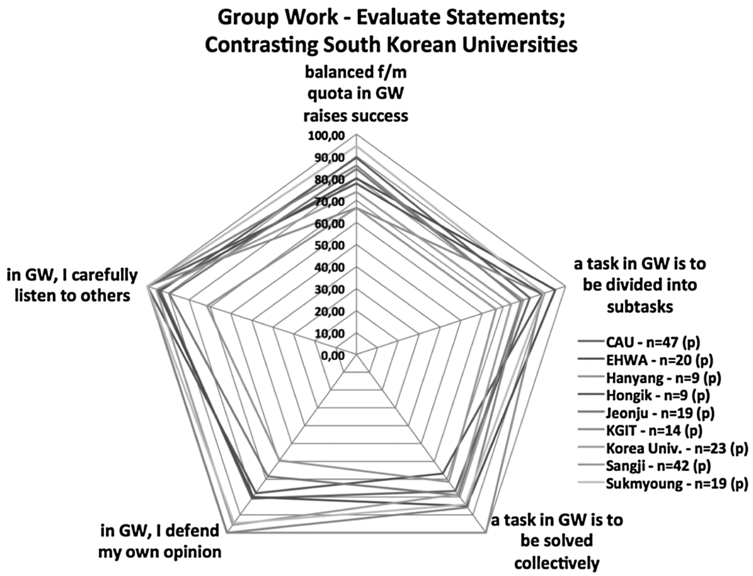

Fig. 3. “Group Work - Evaluate Statements”: South Korean Universities.

Once again, we find very similar patterns when comparing the results of the South Korean universities. In the South Korean sample, we found extreme outliers regarding some thematic blocks, mainly from universities with very small numbers of sample elements and particularly from the KGIT, which just provides extra occupational programs.

3.3 Educational Culture: National Level

In order to evidently conclude that our findings actually had something to do with culture on a national level and not just with university traditions, which, by coincidence, were found to be similar, we needed to find clear differences between the averages of the German and the South Korean universities. We did not expect to find such differences regarding all thematic blocks but surely regarding the thematic blocks “Tasks of the Lecturer” and “Role of the Lecturer”. South Korean universities, by law, must employ one professor per each 10 registered students. In Germany, no such regulation is defined which often results in very crowded classes and rather anonymous students who do not expect any services from their professors apart of being responsible for a lecture and providing evaluations. Thus, the expectations, which South Korean students assign to their lecturers, are far higher, and the student-lecturer relationship is much closer. Further on, South Korean students would never question their lecturers but instead expect them to always provide the best possible solution for a specific problem. German students, in contrast, explicitly learn from the very beginning to put everything into question. Figure 4 displays both national university averages regarding the thematic block "Role of the Lecturer".

Figure 5 displays the average of both national datasets regarding the thematic block "Tasks of the Lecturer". As expected, regarding the items "technical support", "support for the individual literature research", and "support for the organization of the individual learning process", the expectations of the students were very different between both national contexts. While the responses of the German students were indifferent towards all three items (results between 40 and 60 %), the Korean students did very clearly demand related services.

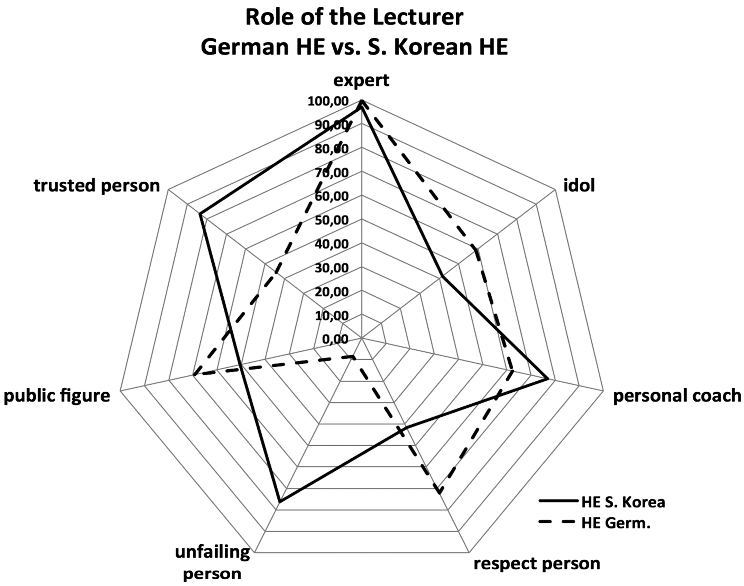

Fig. 4. "Role of the Lecturer": Comparing German with South Korean HE-results.

The results of both national contexts fully confirmed what we expected to find from our experiences. Regarding other thematic blocks, prior known differences also were mostly reflected. Where we actually found amazing results in the South Korean context was regarding the thematic block "Feedback". Because of the Asian concept of shame, we had expected that criticism generally would be a tough issue for the South Korean students. Instead, the students reported to actually perceiving (constructive) critique towards their work results and study progress as motivating. They even reported to feel confused if critical feedback would be missing in the end.

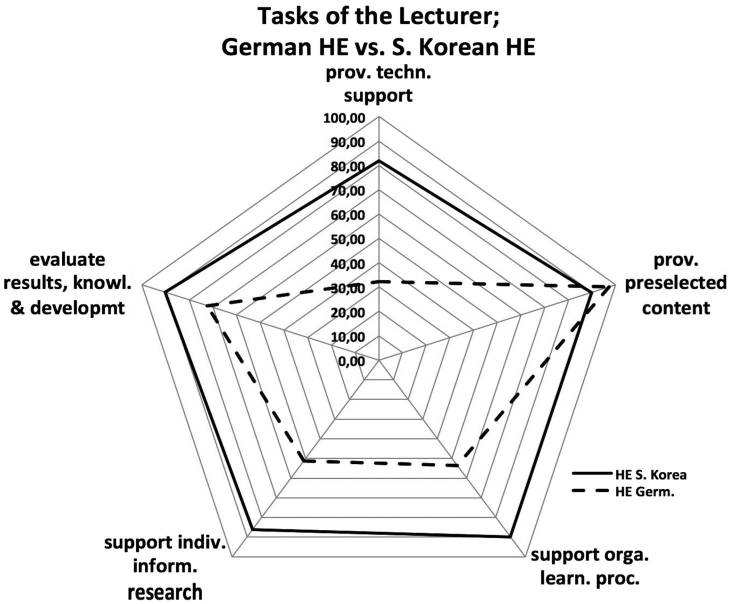

Fig. 5. "Tasks of the Lecturer": Comparing German with South Korean HE-results.

3.4 Findings Regarding Educational Culture in Professional Training

We evaluated the results of the two enterprises that provided seven and 14 sample elements. We found significant differences between the learning cultures of each of the groups of employees, which were in line with the basically different organizational cultures of the enterprises. As displayed in Fig. 6, the results additionally differed a lot from the results from the German universities. For example, instructors in Adult Education (AE) are expected to provide a higher level of leaner-support than in the context of Higher Education (HE).

Another example for such differences we found was related to the role of the instructor/professor in both contexts: Different to professors in Higher Education, instructors in professional training were not perceived as respect persons but just as experts in their field. Both results fully reflect the different situations between higher education and professional training: While learning is expected to be a full-time job for university students, professionals often must manage their training besides their regular work. Thus, efficiency of time usage plays a far higher role for the professionals than it does for the students. Another significant example was found in the context of group work: Different to the context of Higher Education, group work in professional training generally was perceived as difficult, and learning tasks were reported to rarely being completed in time [27].

3.5 Persistence of Learning Culture

From our repetitive study, which took place in the Winter 2014/15 at the University of Applied Sciences Bonn-Rhein-Sieg, we learned that Learning Culture appears to slightly

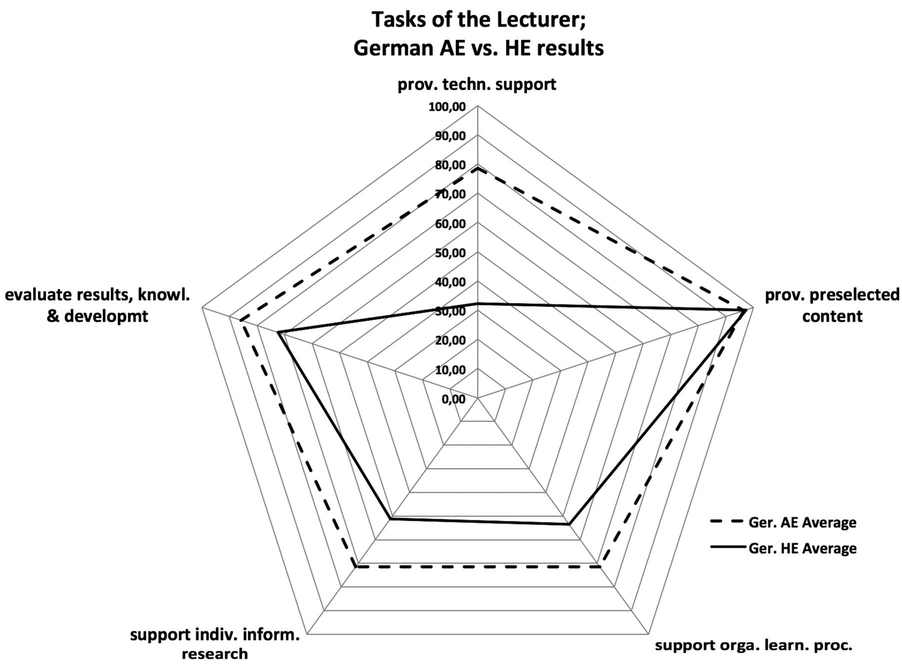

Fig. 6. "Tasks of the Lecturer": German Enterprises (AE) vs. Higher Education (HE).

change in accordance with changes of educational practices on faculty level while the average university results kept almost the same. For example, in 2010, the department of Forensic Sciences had recently started with just a very small number of students. In that time, we found the students perceiving their lecturers much more as coaches than in 2014, when the number of students studying Forensic Sciences was much higher (see Fig. 7).

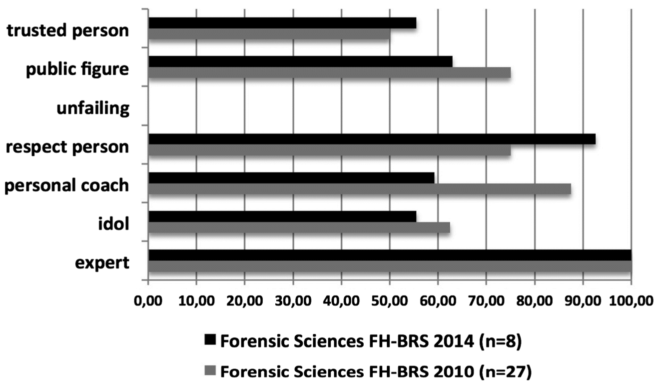

Fig. 7. "Role of the Lecturer": Learning Culture between 2010 and 2014 (Forensic Sciences).

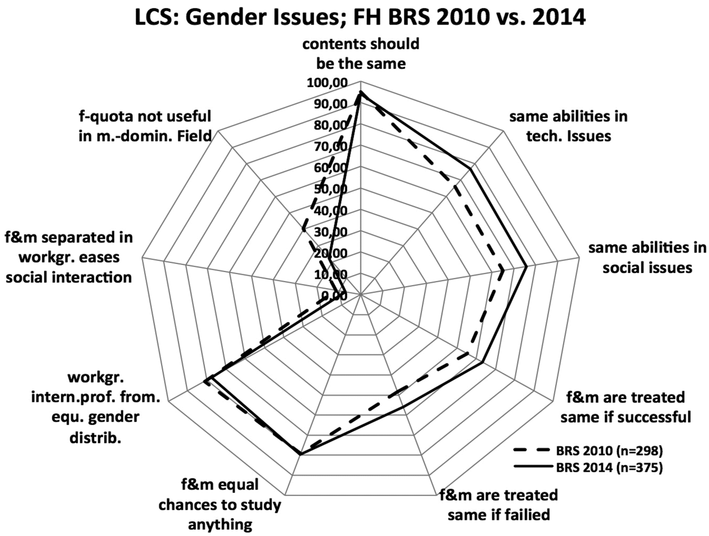

Fig. 8. "Gender Issues": Learning Culture between 2010 and 2014.

Almost no deviations larger than 10 % were found between the average results from both studies on university level. Figure 8 shows the thematic block "Gender Issues" with the highest found level of deviation.

The changes fully reflected the German "Zeitgeist": Currently, an intensive public discussion started regarding the legal enforcement of a female quota for Top-Management positions.

3.6 Limitations

Besides the fact that educational culture varies between academic and professional education and thus, the results of the LCS are not transferable across educational contexts, we found significant deviations between our test studies from British and French Cameroon. Table 1 shows the results of an a-prori/posteriori analysis. From the each 30 sample elements, just a single one was wrongly assigned to the characteristics of the other context (see also Fig. 9).

Table 1. "Motivation": A priori/posteriori classification from HE in British & French Cameroon.

From/to	British	French	Total	% correct
British	29	1	30	96.67
French	1	29	30	96.67
Total	30	30	60	96.67

Note. $N_{total} = 60$; $N_{British} = 30$; $N_{French} = 30$

Our results from the context of education clearly show that we cannot generally assume Learning Culture as a national phenomenon and thus, being homogenous across different societies within nations.

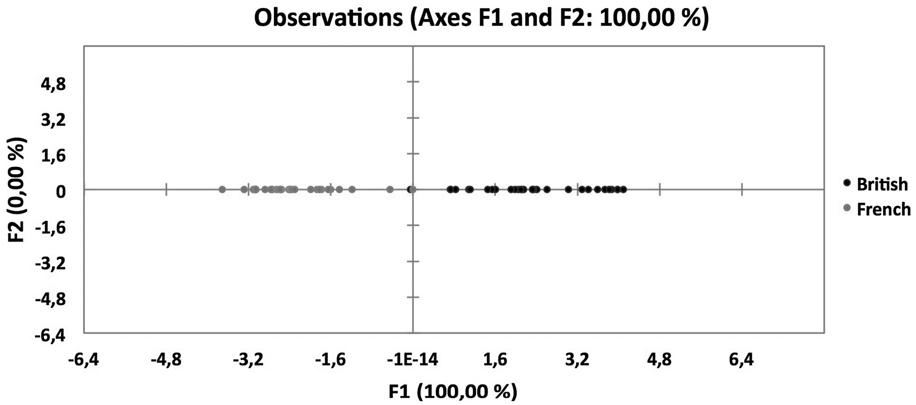

Fig. 9. "Motivation": A-priori & posteriori classification (British & French Cameroon).

We much more expect that found examples of nations that show such a homogenous educational culture must rather be perceived as very rare and exceptional cases.

4 Determining Conflicts in Education

Being able to recognize cultural differences regarding selected issues across educational contexts is not yet sufficient for understanding or even determining at which level a particular cultural distance could eventually lead to a conflict situation and maybe become a threat for the motivation of learners. Cultural distance has been a subject of discussion since some decades. A clear definition of the term does not exist but it originally was used in the context of etic culture research in which the cultures of whole societies were quantified and compared according to a small number of key values (such as provided by the dimensions model of Hofstede et al. [12]). Shenkar [28] criticized the general concept of cultural distance as creating the illusion of an easy way to measure something, as complex as culture that actually is not fully comprehensible at all. Chen [29] and Hatakka [30] argued if quantifying cultural barriers generally would make sense. They claimed that reasons for such barriers and related conflicts might not be limited to isolated culture-specific aspects, but rather base result from a whole set of characteristics including ones' individual ability to deal with unexpected situations. In the field of Technology Enhanced Learning, Pirkkalainen et al. [31] revived the term "cultural distance" with the meaning to determining individual reasons for selected culture-specific barriers against the production, usage, and/or repurposing of Open Educational Resources.

The whole discussion on how to quantify culturally relevant aspects through key-values for whatever purpose appeared like circling around and did not lead us to a solution in terms of finding measures for conflict detection and prevention. What if the concept of quantification itself simply is not adequate for our purpose? Pless and Maak [32] suggested generally not to understand culture as static set of variables, but as a measure to which extent people within a society tend to accept deviations from what they would consider to be appropriate. This understanding of culture appeared promising for our purposes.

Until some years ago, in Germany, the "Central Office for the Allocation of Places in High Education" ("Zentralstelle für die Vergabe von Studienplätzen") assigned students who wanted to study in a specific field to more or less random universities. This means that generally it was assumed that qualified enough German school leavers were capable to study in whichever university, independent of the institutional culture and local practices. Adopting the idea of Pless and Maak and combining it with the results from the Learning Culture Survey, this would mean that all characteristics provided by German universities would define something like a minimum area of acceptance, and in its' extremes, define the pain threshold. To which extent students can cope with even more extreme situations might differ on individual level.

Our samples included some faculties with extreme characteristics. We assumed these could be used to define the margins of the acceptance level. The investigated South Korean universities, in contrast, included extreme cases, from very small universities to large ones and even a university with exclusively extra occupational programs for adults. We again created net diagrams contrasting both contexts but this time, not according to the individual characteristics or average values, but the whole spectrum between found extreme values. The Figs. 10 and 11 show the results according to the thematic blocks "Time Management" and "Role of the Tutor".

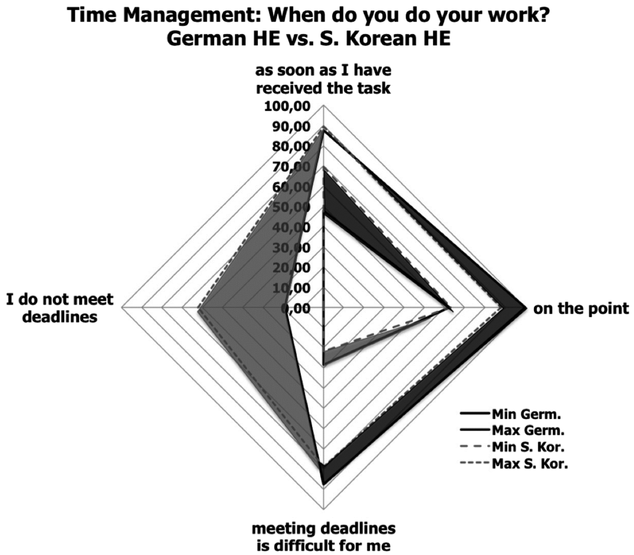

Fig. 10. "Time Management": Contrasting Areas of Acceptance to define Cultural Distance.

For better recognition, we filled the parts of the "acceptance areas" from each context if outside the defined area of the other one, dark for the German (not within the answer spectrum of the South Korean students) and grey for the South Korean.

Figure 10 (on the left side) shows that not meeting deadlines appears to be more accepted in the South Korean context than in the German context. In fact, in South Korean universities, students often get a second chance when they have reasonable excuses why they missed a deadline. Work results of the German students usually will not be accepted anymore after the deadline has expired.

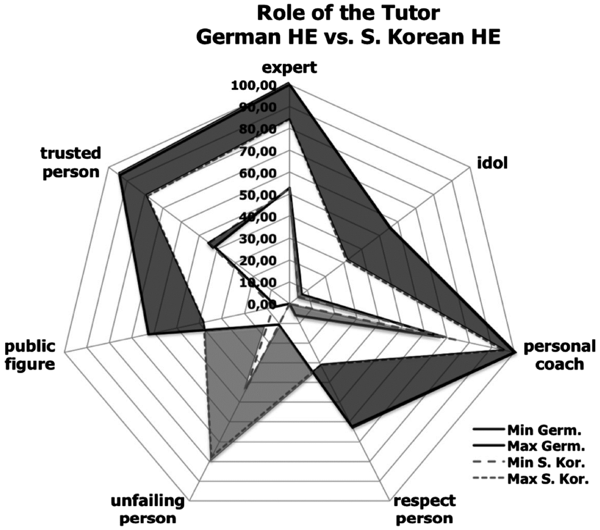

Fig. 11. "Role of the Tutor": Contrasting Areas of Acceptance to define Cultural Distance.

In Fig. 11, the spectra from the thematic block "Role of the Tutor" are contrasted: On the first sight, the result we found in the South Korean context was very surprising for us: The responses of the South Korean students were very similar regarding both of role of the lecturer and the role of the tutor. We particularly could not imagine that tutors (who in our experience are older students) could be considered to be unfailing. In later informal interviews with colleagues in Seoul, we found out that even though tutorials take place in a far more familiar environment than lectures, mostly, the professors themselves hold the tutorials. We do not know if the answers of learners in pure online environments would be the same in this (for us) very particular situation. Further (qualitative) investigations in the South Korean context are scheduled for 2016. This experience particularly showed us that involving native people is essential for the interpretation phase.

5 Learning Culture in the Practice and Best Practice Examples

In this section, practical scenarios are shown, in which the results from the Learning Culture Survey can directly lead or already led to improvements regarding the quality and/or effectiveness of education.

5.1 Speeding Up the Social Integration of Refugees Through Language Lectures

The most current development in Europe and in the world shows the urgent necessity to better understand learning culture and focus on the development of culture-sensible education. The explicitly fostered migration across the European Union membership countries in the context of job-search led to highly international classrooms in schools, which far too often are perceived overburdening for the teachers. The European Commission observed that alongside with the increasing migration, also the number of early school leavers increased. As a reaction, the European Commission declared measures to intervene the early leaving of schools as one of the central aims of its programs educational Erasmus Plus and Horizon 2020. Nowadays, because of wars and discrimination, a very large number of refugees comes into Europe in search for physical but also economical security. They mainly come from Middle East and African, from countries like Syria, Afghanistan, Iraq, Eritrea, Pakistan, Nigeria, Senegal, and others. For the near future, we even expect far more refugees, particularly from such countries that have to deal with ecological catastrophes, which are the consequences of industrialism, amongst them, island states and which even might completely disappear with the ongoing sea level rise.

Germany currently is host for above 250.000 refugees. The number is constantly increasing and for the economy of Germany, these refugees even might actually solve a middle-term problem of negative demographic development and thus are understood as a (temporary) win-win situation; temporary just because their countries of origin might strongly need them back, when the wars are over. However, in order to fully integrate them as members of the German society and into the world of works, it is highly relevant to supporting them to quickly learn the German language. In such cases, it can be assumed that with the understanding and consideration of the refugees' culture-specific needs and peculiarities both will increase, the efficiency of teaching and the acceptance of the taken measures. Since the numbers of available and competent enough teachers who could manage this task also is quite limited, E-Learning might become a crucial supportive technology.

Our results from the Learning Culture Survey alongside with the evaluation of reports on experiences from related educators and learners could prove highly relevant as a supportive measure. We currently started related investigations within an asylum hostel in Bonn, Germany.

5.2 Imparting Cultural Competences to a Multinational ERP-Class

In our bachelor-course on Enterprise Resource Planning (ERP) we decided to move from teacher-centered cognitive design in a face-to-face scenario to a constructivist learner-focused design using a blended learning approach and the basic concept of students-teach-students. Instead of teaching contents that easily can be read in a book, we wanted to support our students to achieve competences, which are required for both their bachelor thesis and their future every day's professional life. Such competences were related to writing (authoring) skills, teamwork, English language skill, communication and collaboration skills, and group/project management.

121 students from different fields had registered for this particular course of which 13 already dropped out after the introduction. The course language was English. While usually providing twelve lecture units per semester in average, the educators held just a single one, which was the course introduction. For the rest of the time, the students were to research in groups of 8–10 and then teach their peers about the results. The educators took the roles as moderators and coaches.

The course consisted of 65 % German and 35 % foreign students, whereas we could not distinguish between guest students and first-/higher-generation immigrants. In order to ensure an intercultural setting for each group and foster the development of intercultural competences as a side-effect of our course, we randomly formed the groups whereas the foreign students were separately assigned in a way that no "national sub-groups" could be formed. Most of the foreign students came from Turkey, Ukraine and Bulgaria, countries in which we already had collected data. Three students came from Russia, two from Asian countries, and each one from Iran and USA.

Our own investigation during and after the course has shown that the found social/cultural conflicts that occurred during our course partly were explainable with the respective country profiles from the Learning Culture Survey (LCS). The culture-specific profiles defined from our results from the LCS further proved helpful in terms of an improved apprehension of particular conflict reasons and to decide about appropriate interventions. Regarding conflict prognostication, we experienced difficulties due several reasons when it comes to attitudes that might be expected from individuals: First, driving conclusions from country profiles to individuals is anyways problematic. Second, educational scenarios like the one we dealt with in our course belong into the context of urban education and not be- or multinational, which we consider to possibly differ from the "original country profiles. Third, it is yet unclear to which extent immigrants and guest-students adopt the local culture and if maybe completely new (fusion) cultures emerge. Last, the aim of intercultural work should lead to a reduction of prejudices. Precasting conflicts on this level would mean to agree with and constitute stereotypes. Further research is required in this field.

5.3 ERP4students

In 2006, the University of Duisburg-Essen implemented their first of the program "erp4students". Fully basing on E-Learning, this program provides opportunities to registered university students for tutor-supported professional training in addition to or even as integral part (accounting the supposed 180 working hours as six ECTS) of their full-time studies. While the first course of erp4students exclusively was available in German language and provided to German students in the field of Information Systems Research, nowadays, students from an increasing number of countries and arbitrary fields of study have access to 13 different SAP-specific courses in up to four languages, achieve the provided highly valued certifications of our university and can even participate in the official examinations of the SAP SE.

It is yet unclear to which extent the courses could profit from a more culture-sensible design. However, language issues actually are a barrier for participation regarding both the courses and the tutorials. It could prove beneficial if the 7/24 available tutor support could be provided from persons who actually live in the same geographical regions as the students. A very different perception of time management could lead to complications in the course completion so that preventive measures appear necessary. We currently are evaluating collected data from the past years and focus our next research phase to this particular multinational E-Learning scenario.

5.4 Open Discovery Space

With 51 partners from 20 European countries and a budget of 15.3 Million Euro, Open Discovery Space is the largest e-Learning project ever launched by the European Commission. The Open Discovery Space project started in April 2012 and is scheduled to end in September 2015. Open Discovery Space focuses on the school sector and aims to design and develop innovative learning methodologies and instruments by promoting and realizing open education. ODS opens up content by centralizing the access to different, mainly European learning content repositories, opens up learning by extending the repositories' functionalities through an own toolset that bases on self-developed solutions on teacher/school level, and additionally, opens up collaboration amongst the diverse stakeholders in the school sector through fostering the open exchange of knowledge, experiences, and educational activities. In order to achieve this goal, a central community platform has been developed and launched, which hitherto focuses and is implemented on the European level, but also can individually be implemented on school, regional, and/or national level and accessed from anywhere in the world.

Open Discovery Space clearly must be understood as a best practice example for an environment supporting culture sensible education because

- it provides an multilingual interface;
- the implemented keyword-based search functionality does uses a LOM-compatible international dictionary for key-terms and recommends educational resources in any stored language additionally to the one originally used in the search query;
- it supports group formation of virtual groups and communication on freely definable levels, locally, nationally, or across countries in any constellations of role bearers.

These features and others empower educators particularly in scenarios like school classes with extreme international character to better support their learners because in case of need, they easily can find and provide supplementary learning resources in the languages of their learners dealing with the same or similar contents like the own ones taught. This approach already works perfectly in an inclusive reference school in Germany where children with very individual special needs are to be supplied with specific learning resources. In cases of trouble on the social level and others, educators can easily get in touch with colleagues from their learners' original context through the social platform and ask for support, e.g. for sharing educational strategies. We think that the results from the Learning Culture Survey can additionally enrich the portfolio of opportunities in order to support the educators' but also the learners' understanding of cultural diversity.

6 Conclusions

Culture often is promoted as something that easily can be reduced to a small number of dimensions and basic values. As such, it is understood as a set of characteristics that apply to all people within nations in the same measure without regard of their particular life situations. Our research on educational culture of the past years revealed fundamental restrictions against such a generalization and transferability of results across educational contexts (school education, higher education, professional training). Against common practice, we additionally found that age and language influenced the culture-related perceptions of our investigated learners.

After we found that this commonly promoted concept of culture does at least not apply to the context of education [27], we had to reconstruct our understanding of culture before starting further investigations. Our currently completed longitudinal study in the context of the Learning Culture Survey provided the last missing evidence that educational culture is persistent enough on university level so that initializing an international collection of related data on a large scale actually makes sense. Further on, our quantitative results from the Learning Culture Survey questionnaire revealed appropriate to recognize, measure, and understand cultural differences in the context of education.

While we currently collect our data just in the context of traditional (face-to-face) education, we assume that the results are fully transferable to Technology Enhanced Learning; at least for learners and educators who are used to traditional forms of education and newly enter such a scenario. An extension of our studies to educational programs that exclusively offer online access is planned for the next years.

The datasets from the Learning Culture Survey enable learners and educators who are going to study and/or teach in other cultural contexts (online or offline) to start their efforts with a better understanding of the expectable peculiarities. In terms of conflict prevention, learners can adjust their initial expectations and find out about commonly accepted behavior in the targeted context (e.g., higher education in a specific country). Educators get an impression of the reasons for particular attitudes of their future learners and can develop a better understanding of their needs in terms of adopting their own accustomed teaching design (and practices) to the new conditions.

The data can also be used in the retrospective, in order to find the origins of repeatedly occurring culture-related conflicts in distinguished educational settings (possibly even resulting in higher dropout rates): On the basis of the issues considered in the Learning Culture Survey, monitored events and situations can systematically be analyzed for possible reasons (see e.g., [33]), improvement potential can be determined, and the next generation of learning design can be defined accordingly.

As for forecasting of possible educational conflicts, the approach to define cultural distance and related conflict potential on the basis of the level of acceptance is demanding but the results appear promising. However, even if one day, we will be able to determine conflict potential in specific educational settings, we will never be able to generally prevent all possible culture-related conflicts in education. We have too little understanding of additional influences and particularly, cross effects between different influence factors. Anyways, for specific situations and constellations, we eventually are/will be able to estimate where culture-related conflicts are likely to emerge. Further research is required on this issue and planned for the next years.

The results of our longitudinal study indicate that, on faculty level, the LCS reflects the students' reaction on changes in their own learning environments. We have the intention to investigate to which extent this finding could reveal helpful in the context of impact management and quality management.

7 Next Steps and Call for Contribution

With our questionnaire our and hitherto achieved understanding of educational culture, we are able to conduct standardized investigations regarding particular issues in different national and educational contexts and compare found results across contexts. We yet lack the understanding to explain (in detail) the reasons for found results. For this purpose, additional qualitative investigations need be implemented as follow-ups. We are currently developing standardized methods that enable us not only to pointedly investigate reasons for certain cultural perceptions and attitudes of learners but which additionally are similar enough to lead to results that eventually are comparable across contexts.

We are constantly extending our database and looking for opportunities to conduct the LCS in further educational contexts. Our long-term aim is to develop and provide an open database on educational culture. This database shall support both educators and learners all over the world to better understand other contexts' educational cultures. Such an understanding is essential, particularly when having to cope with the demands of culture-sensible education in international classrooms or with too highly or wrongly set expectations.

However, for that purpose we need a lot more reliable data from all over the world. Hence, we would like to invite other researchers and educational institutions to take part and contribute to the Learning Culture Survey.

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References

1. Hoffmann, S.: Schulabbrecher in Deutschland – Eine bildungsstatistische Analyse mit aggregierten und Individualdaten. Diskussionspapiere, No. 71, Friedrich-Alexander Universität, Erlangen-Nürnberg (2010)
2. Haberman, M.: Star Teachers of Children in Poverty. Kappa Delta Pi, West Lafayette (1995)
3. Richter, T., Adelsberger, H.H.: E-learning: education for everyone? Special requirements on learners in internet-based learning environments. In: Proceedings of the EdMedia 2011, pp. 1598–1604. AACE, Chesapeake, VA (2011)

4. Nilsen, H.: Action Research in Progress: Student Satisfaction, Motivation and Drop Out Among Bachelor Students in IT and Information Systems Program at Agder University College, Nokobit. Tapir Akademisk Forlag, Nokobit (2006)
5. Bowman, R.F.: How can students be motivated: a misplaced question? Clearing House **81**(2), 81–86 (2007)
6. Rothkrantz, L., Dactu, D., Chriacescu, I., Chitu, A.G.: Assessment of the emotional states of students during e-Learning. In: Proceedings of the International Conference on e-Learning and Knowledge Society, pp. 77–82 (2009)
7. Sandanayake, T.C., Madurapperuma, A.P.: Novel approach for online learning through affect recognition. In: Proceedings of 5th International Conference on Distance Learning and Education, pp. 72–77. IACSIT Press, Singapore (2011)
8. Jones, M.L.: Hofstede – Culturally questionable? In: Proceedings of the 2007 Oxford Business & Economics Conference, Oxford University, Oxford (2007)
9. Leidner, D., Kayworth, T.: A review of culture in information systems research: toward a theory of information technology culture conflict. Manage. Inf. Syst. Q. **30**(2), 357–399 (2006)
10. Hofstede, G.: Culture's Consequences – International Differences in Work Related Values. Newbury Park, London (1980) [herein used the 2nd edition from 2001]
11. Smith, P.B.: When elephants fight, the grass gets trampled: the GLOBE and Hofstede projects. J. Int. Bus. Stud. **37**(6), 915–921 (2006)
12. Hofstede, G., Hofstede, G.J., Minkov, M.: Cultures and Organizations: Software of the Mind, 3rd edn. McGraw-Hill Publishers, New York (2010)
13. Köppel, P.: Kulturerfassungsansätze und ihre Integration in interkulturelle Trainings. Trierer Beiträge zur gegenwartsbezogenen Ethnologie. Fokus Kultur, Trier (2002)
14. Douglas, I., Liu, Z.: Global Usability. Springer, London (2011)
15. Tarras, V., Steel, P.: Beyond Hofstede: challenging the ten commandments of cross-cultural research. In: Nakata, C. (ed.) Beyond Hofstede: Culture Frameworks for Global Marketing and Management, pp. 40–60. Palgrave Macmillan, New York (2009)
16. Oetting, E.R.: Orthogonal cultural identification: theoretical links between cultural identification and substance use. In: de la Rosa, M.R., Andrados, J.-L.R. (eds.) Drug Abuse Among Minority Youth: Methodological Issues and Recent Research Advances, pp. 32–56. National Institute on Drug Abuse (DHHS/PHS), Rockville, MD (1993)
17. Mitra, S., Dangwal, R., Chatterjee, S., Jha, S., Bisht, R.S., Kapur, P.: Acquisition of computing literacy on shared public computers: children and the "hole in the wall". Australas. J. Educ. Technol. Nr. **21**, 407–426 (2005)
18. Buehler, E., Alayed, F., Komlodi, A., Epstein, S.: "It Is Magic": a global perspective on what technology means to youth. In: Proceedings of the CATaC 2012 Conference, pp. 100–104 (2012)
19. Richter, T.: Adaptability as a special demand on open educational resources: the cultural context of e-learning. Eur. J. Open Distance E-Learn. EURODL **2**, 1-12 (2011)
20. Richter, T.: The Learning Culture Survey: An International Research Project on Cultural Learning Attitudes. English language Questionnaire Version for Recognition. Due-Publico, Essen (2014)
21. Müller, H.-P., Kock Marti, C., Seiler Schiedt, E., Arpagaus, B.: Atlas vorkolonialer Gesellschaften. Reimer, Berlin (2000)
22. Garland, R.: The Mid-Point on a Likert-Scale: Is it Desirable? Marketing Bulletin, 2/1991, Research Note 3, pp. 66–70 (1991)
23. Baur, N.: Das Ordinalskalenproblem. In: Baur, N., Fromm, S. (eds.) Datenanalyse mit SPSS für Fortgeschrittene, 2nd edn, pp. 279–289. VS Verlag, Wiesbaden (2008)

24. Knapp, T.R.: Treating ordinal scales as interval scales: an attempt to solve the controversy. Nurs. Res. **39**(2), 121–123 (1989)
25. Porst, R.: Fragebogen: Ein Arbeitsbuch: Studienskripten zur Soziologie. 1st Ed., VS Verlag für Sozialwissenschaften, GWV Fachverlage, Wiesbaden (2008)
26. Kromrey, H.: Empirische Sozialforschung, 11th edn. Lucius & Lucius, Stuttgart (2006)
27. Richter, T., Adelsberger, H.H.: On the myth of a general national culture: making specific cultural characteristics of learners in different educational contexts in Germany visible. In: Proceedings of the CATaC 2012 Conference, pp. 105–120 (2012)
28. Schenker, O.: Cultural distance revisited: towards a rigorous conceptualization and measurement of cultural differences. J. Int. Bus. Stud. **32**(3), 519–535 (2001)
29. Chen, Q.: Use of open educational resources: challenges and strategies. In: Tsang, P., Cheung, S.K.S., Lee, V.S.K., Huang, R. (eds.) ICHL 2010. LNCS, vol. 6248, pp. 339–351. Springer, Heidelberg (2010)
30. Hatakka, M.: Build it and they will come? Inhibiting factors for reuse of open content in developing countries. Electron. J. Inf. Syst. Developing Countries **37**, 1–16 (2009)
31. Pirkkalainen, H., Jokinen, J., Pawlowski, J.M., Richter, T.: Overcoming the cultural distance in social OER environments. In: Proceedings of the CSEDU 2014, pp. 15–24, SCITEPRESS, Portugal (2014)
32. Pless, N.M., Maak, T.: Building an inclusive diversity culture: principles, processes and practice. J. Bus. Ethics **54**(2), 129–147 (2004)
33. Richter, T., Adelsberger, H.H.: Cultural country profiles and their applicability for conflict prevention and intervention in higher education. In: Stracke, C.M., Ehlers, U.-D., Creelman, A., Shamarina-Heidenreich, T. (eds.) Proceedings of the European Conference LINQ & EIF 2014, pp. 58–66. Logos Verlag, Berlin (2014)

A Remotely Controllable Thermo-Vacuum Facility for Testing Small Payloads

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Abstract. A fully equipped thermovacuum facility has been designed and assembled at Sapienza University during the development phase of LARES, a satellite of the Italian Space Agency. After the launch of the satellite in year 2012, the facility has been devoted to testing small payloads and cubesats. An upgrade of the facility allows some operations to be performed remotely. It is planned to complete the automation of the operations so that the majority of the tests could be monitored and controlled from home or during the lectures from the class. The paper will describe the facility, some test campaigns performed recently and the recent advances in remote operations.

Keywords: Thermo-Vacuum testing · Space simulator · E-Learning

1 Introduction

Qualification of space components is an activity of paramount importance since in case of failure in space there is no possibility of convenient intervention. However, we recall some exceptions such as the repairing and upgrading in orbit, with the Space Shuttle servicing missions, of the Hubble space telescope. The complex operations were carried out by five very expensive human missions. Recently a satellite servicing capabilities office has been established at Goddard Space Flight Center which will provide robotic servicing technology not only for repairing but also for maintenance and satellite disposal. It has to be considered that although robots are far less expensive than astronauts, the costs of those operations are anyway much higher than qualification tests. That is particularly true for the small payloads: the cost of a servicing mission would be probably higher than the mission itself.

In the case of LARES satellite it was of vital importance to test the Cube Corner Reflectors (CCRs) under operating conditions, reproduced inside the thermo-vacuum,

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Fig. 1. Internal test volume of the vacuum chamber. The five walls visible in black are painted with Aeroglaze Z306. A smaller nitrogen cooled shroud, used for some tests, is visible just behind the small shaft that is attached to the rotational manipulator at the top of figure.

chamber, in order to verify the CCR functionality [1]. Although the cost of the facility was relatively high, that would never compare with the cost of the mission. The satellite objective was to test frame-dragging [2, 3] of general relativity theory with an unprecedented accuracy, bringing the error from 10 %, already obtained with the LAGEOS satellites [4], to about 1 % [5] as also shown with a Monte Carlo simulation [6]. LARES was successfully put in orbit February 13, 2012 [7] and is perfectly operating since then [8],

Fig. 2. The liquid nitrogen cooled shroud removed from the chamber, with the brazed copper coil visible.

thus demonstrating the goodness and the reliability of the tests performed in the vacuum chamber. Although the satellite data analysis is still in progress [9], from the first measurements it has been verified that it behaves as the best test particle available in the solar system [10]. Behaving as an almost ideal test particle means that it can be used to probe very accurately the gravity field around Earth thus providing the scientists with the possibility of verifying the deviations of the orbit from classical Galilei-Newton mechanics.

2 Description of the Facility

The main component of the facility is the vacuum chamber that has cubic shape of 0.6 m side. Five walls are entirely covered with a copper shroud painted with Aeroglaze Z306

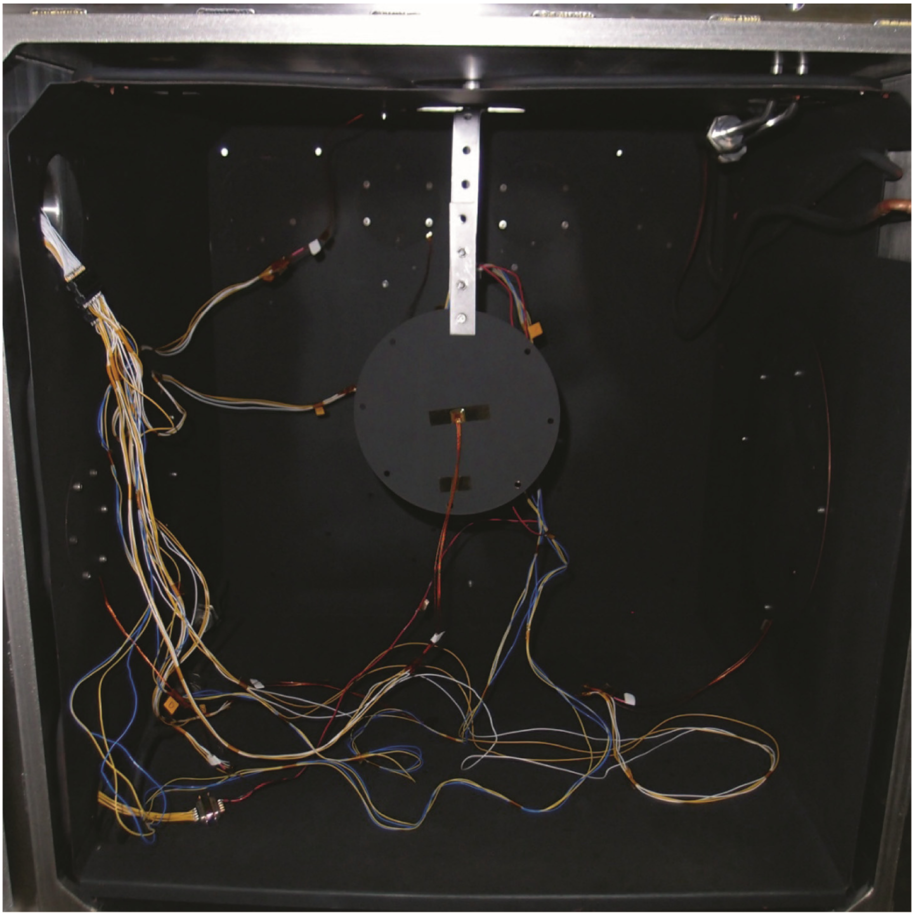

Fig. 3. The black disc in the middle of the chamber is in contact with the upper wall and cools down to −90°C. Equipped with resistive heaters for thermal control the disc can be maintained at −18°C to simulate Earth infrared radiation.

which is a special paint with thermo optical properties ($\alpha > 0.95$ $\varepsilon = 0.90$) that approach those of an ideal black body (Fig. 1) [11]. Copper coils are brazed (i.e. joined to the shroud by melting a silver alloy filler) (Fig. 2). The cooling circuit is open-loop, i.e. liquid nitrogen will flow from the Dewar, positioned outside of the lab, through a thermally isolated pipe into the coils inside the chamber and then, through a second thermally isolated pipe, released in the air outside the lab. The upgrade with a closed-loop re-liquefaction apparatus is possible but not convenient because many thermo vacuum tests are performed according to the European Cooperation for Space Standardization ECSS-E-10-03A/C [12, 13], which requires only thermal cycling in vacuum and in the temperature range from the minimum to the maximum temperature limits expected during operation (which in Low Earth Orbit, LEO, means usually not under −34°C) [14]. In the next section it will be described an upgrade of the facility with an additional cooling system which fulfill the ECSS just mentioned.

The five wall shroud has several apertures in correspondence to the chamber feedthroughs, but it is possible to cover those in case the feedthroughs are not used in a particular test: that arrangement is to reduce the number of hot spots on the walls as much as possible. The door wall has a feedthrough which can be used for feeding an additional liquid nitrogen cooled shroud, but currently it is preferred the use of a disc which cools down to about −90°C which is sufficient for most tests. The cooling of this disc is obtained by radiation heat transfer with the other walls and by conduction, through the support, with one of the walls (Fig. 3). The five wall shroud is modular, in fact the floor can be removed, provided the liquid nitrogen coil is reconnected using the Swagelok fitting (Fig. 4) that guarantee perfect sealing and a relatively easy screwing and unscrewing. The shroud has been designed with this possibility because of the

Fig. 4. The Swagelock fittings can be used to remove the cooled floor of the shroud if needed, to test heavy specimens.

deformability of the thin copper shroud which cannot support weight higher than say 5 kg without experiencing macroscopic deflection of the shroud itself.

The chamber is equipped with three optical windows, the largest one has a minimal absorption in the solar extraterrestrial spectrum and is used for illuminating the test item with the solar simulator (Fig. 5, in the photograph the sun simulator has been temporarily removed to allow the view of the window). The second largest one has an optical quality of λ/20 (where λ is the light wavelength) and is required for testing, with instrumentation placed in air, optical payloads inside the chamber (Fig. 6). The third optical window is very small, positioned on the front door, and is used for visual inspections (visible in Fig. 5). A led strip is fixed on the internal part of the door to illuminate the enclosure. The side wall on the left is equipped with two electrical feedthroughs with 50 and 9 pins respectively. The first is used for transferring sensor readings to an outside acquisition system and the second mainly to power resistive heaters and illumination leds (Fig. 6).

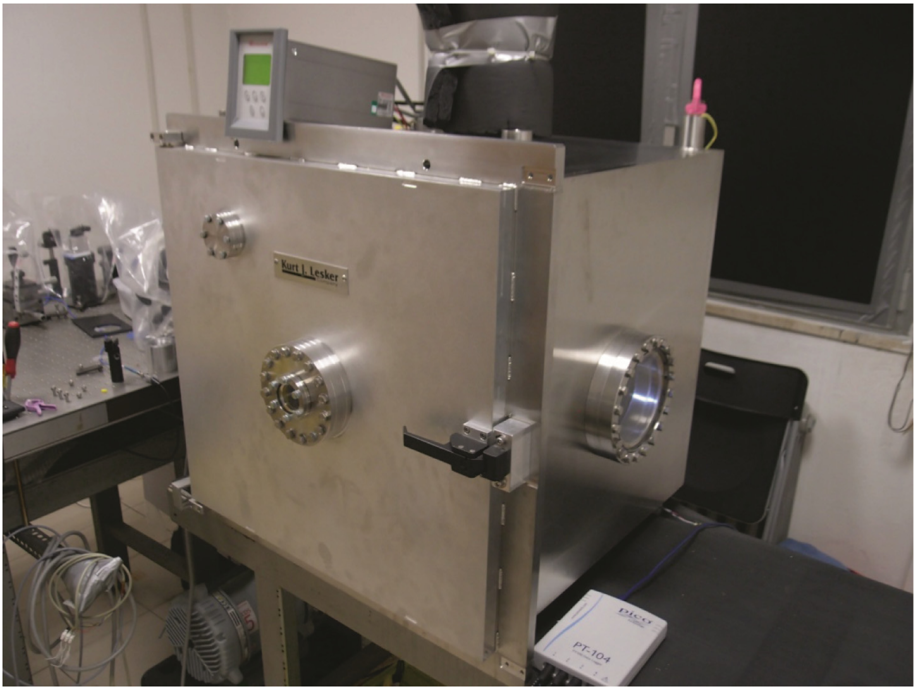

Fig. 5. The vacuum chamber, closed. The window on the right is used to illuminate the specimen under test with the beam of a Sun simulator lamp (not present in the photograph). The smaller window on the door is an inspection window.

3 Testing Activities

In this paragraph two test campaigns with different experimental set-ups will be briefly described. The first one concern the tests performed on the CCRs of LARES satellite. The second is relevant to the test performed on the 3U CubeSat (TIGRIsat) for validation of a numerical thermal model of the hardware.

3.1 CCR Testing

The LARES-Lab facility has been designed specifically to test the optical payload of LARES satellite [15]. LARES carries 92 CCRs which are used to measure the position of the satellite with an accuracy that can reach fractions of a centimeter [16]. The International Laser Ranging Service (ILRS) [17] operates a network of about 60 ground stations which measure the distance of satellites equipped with CCRs and other types of retro-reflectors by shooting laser pulses toward the spacecraft. The CCRs reflect the pulses toward the ground station regardless of the orientation of the reflectors; the distance of the satellite is then calculated by accurately timing the time-of-flight of the laser pulses. The ranging data provided by the ILRS are then processed by analysis centers; LARES data are processed by the International Space and Time Analysis Research Centre (ISTARC) located in Rome at Sapienza University [18], that provides the orbital predictions for the spacecraft.

LARES CCRs are made of Suprasil 311 optical glass; back faces of the CCRs are uncoated, the laser pulses are sent back from the front face after three total internal reflections (Fig. 7). The dihedral angles between the back faces of the CCRs mounted on satellites must be corrected for the so called velocity aberration: the back faces are manufactured introducing a small angle offset to compensate the effect of the satellite motion on the reflected signal. The offset re-distributes the energy of the reflected diffraction pattern (Far Field Diffraction Pattern, FFDP) so that the peak of the reflected energy is not in the center of the FFDP but is distributed on an annulus; this way the ground station will fall inside the annulus. On LARES the offset on the dihedral angle was 1.5 ± 0.5 arcsec. The small manufacture tolerance allowed on the offset angle could have been disrupted by temperature gradients on the CCRs due to the environmental condition in orbit and the thermo-optical properties of tungsten alloy used for the satellite body, a material that is somewhat "anomalous" for space structures. A temperature difference ΔT between the front face and the apex of the CCR will produce a change in the dihedral angle proportional to $\alpha_T\ \Delta T{\cdot}D$, where D is the front face diameter and $\alpha_T = 5.1 \times 10^{-7}\ \text{K}^{-1}$ is the coefficient of linear thermal expansion of the Suprasil. The tests in the LARES-Lab were used to determine an experimental value for the expected ΔT [19] and to measure the deformation of the FFDP, having reproduced for the CCRs the best simulated operational conditions [20].

Fig. 6. The high precision optical window for optical testing. Above the window is mounted the turbo molecular pump over a vibration damper (in red). The same side of the chamber hosts the electrical feedthroughs (top and bottom right) (Color figure online).

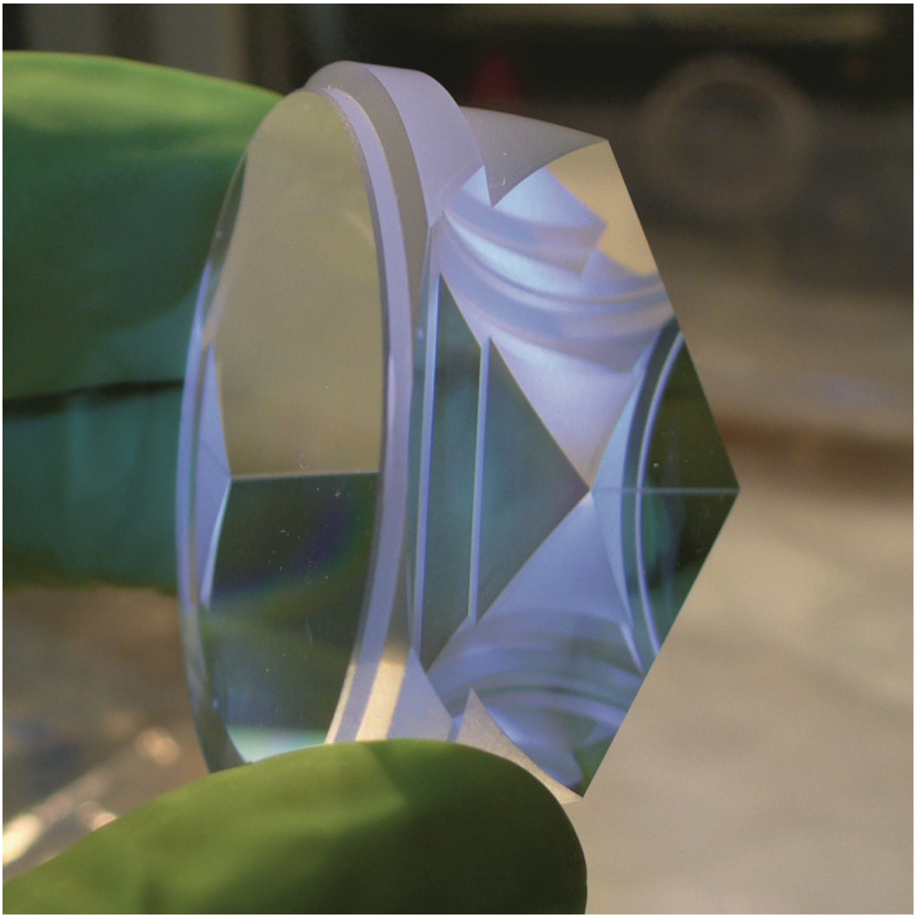

Fig. 7. A CCR of LARES satellite. The front face and the back faces are uncoated: laser pulses are reflected back to the ground station by three total internal reflections.

3.2 Thermal Testing of Tigrisat Structure

In 2012 Sapienza University of Rome in collaboration with the Task Force Iraq (Italian Ministry of Foreign Affairs), the Iraqi Ministers of Science and Technology, High Education and Transport, and the Italian Air Force, organized the First High Level Postgraduate Course in Aerospace Engineering. The participants to the course were a group of Iraqi engineers that, together with Sapienza University, designed and built the first Iraqi satellite, TIGRIsat, for monitoring sand and dust storms over Iraq. The satellite was then successfully launched in 2014, deployed by Unisat 6, a bigger satellite (developed and built by Gauss srl, Rome Italy) launched by a Dnepr rocket from the Yasny cosmodrome (Russia) [21]. The small satellite, a 3U CubeSat, carries, as main payload, an RGB wide field camera and is also a test-bed for technologies developed at Sapienza University, such as the active magnetic attitude control system, the S-Band antenna and the on-board computer [22, 23]. Because of the limits on mass and volume of the CubeSat design, and the limited power supplied by the solar cells, TIGRIsat relied on passive thermal control. So the thermal analysis was critical to assure that the satellite components (camera, battery, computer) would stay within the allowed operational limits once in orbit. To determine the temperatures on the satellite a numerical model was developed, that simulates the main components of the satellite and the worst environmental conditions in orbit. It is well known that the absorptivity over emissivity ratio (α/ε) of the satellite structure, made of aluminium alloy, was the key parameter to obtain passive thermal control. However, the α/ε ratio of the material was not known, and measuring directly α and ε was not an easy task. The solution was found testing one section of the structure in the thermo-vacuum chamber. The structure of the satellite is made of 3 cubic units (3U), side 10 cm each; one section of the structure, without the subsystems, was suspended inside the vacuum chamber and equipped with thermal sensors (Fig. 8). The structure was illuminated with the Sun simulator beam on one side, while 5 walls of the chamber were cooled with liquid nitrogen ($T = -192$°C) and the sixth side hosted the Earth infrared simulator ($T = -18$°C). The numerical thermal model was tuned on the α/ε ratio until the temperatures in the model matched the temperatures recorded on the structure during the thermo-vacuum test. The test has shown that the α/ε ratio of the metal was 0.237, a value that allows an optimal passive thermal control

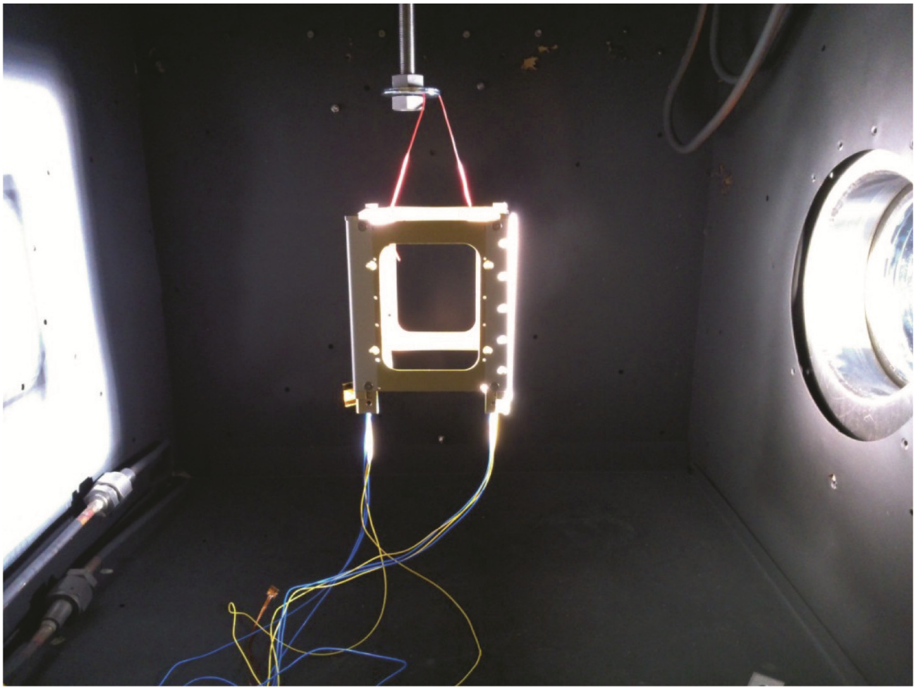

Fig. 8. One unit of the 3U structure of TIGRIsat during the thermo-vacuum test [24]. The structure is illuminated by the Sun simulator beam entering the window on the right. The cables are for the temperature sensors.

without needing coating or painting the external surfaces of the metal. The telemetry data from the operational satellite are confirming the correctness of the analysis and testing [24].

4 Facility Upgrade and Relevant Remote Control

Sometimes tests run over a long period of time, and in those cases it would be convenient to have remote access to the controls of the facility. The additional cost for automation is relatively accessible giving the facility an increased potential, being possible to conveniently run tests also overnight. Particularly interesting is the use for didactic purposes: the possibility during the class not only to show a running test, but also interact with the facility by acquiring data and providing inputs. Furthermore access through internet will allow, with proper permissions, to control the test from home or anywhere else.

Remote operation of labs, test machines and simple manufacturing processes for teaching is a recent trend, which will be further exploited in the future [25–29]. However a search in the available literature did not produce any example of remote operated space environment simulators [30]. Didactic activities of the Aerospace Engineering University courses include experiment about thermodynamics, heat transfer and thermal control, focused on space components, and testing of small payloads for space mission, or even design and testing of microsatellites (such as CubeSats). Indeed, from 2000 the

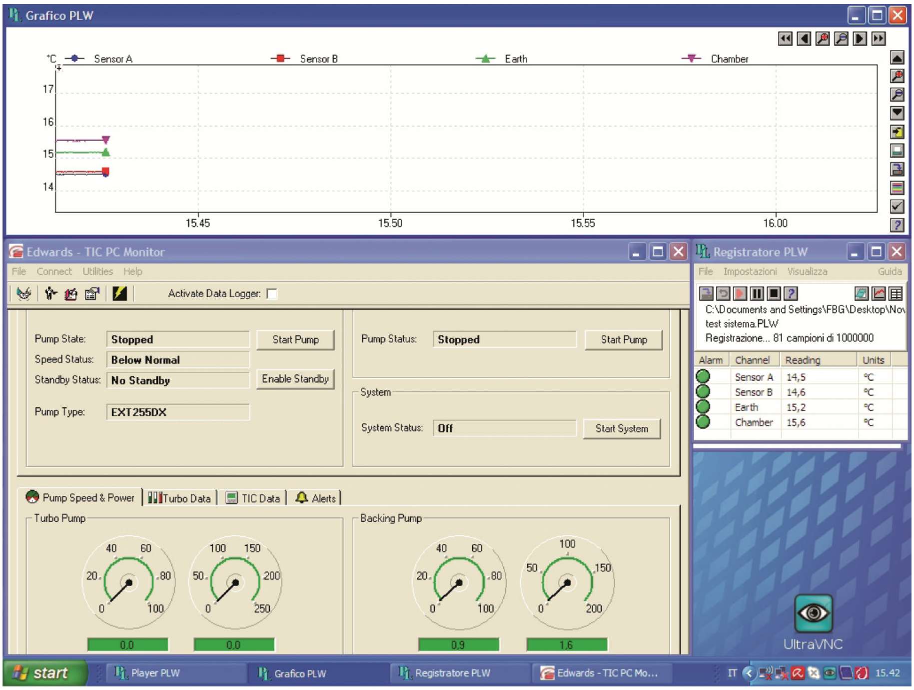

Fig. 9. A screenshot from the server PC, showing the softwares for temperature monitoring (top and center right), for the turbomolecular pump control (down) and for pressure monitoring (not shown in this screen shot). The VNC icon is also visible bottom right) [30].

School of Aerospace Engineering of Sapienza University of Rome launched several microsatellites and nanosatellites developed by students, PhD students and students of postgraduate courses [31, 32]. Some of these microsatellites or some payloads where tested in the LARES-lab thermovacuum facility. Some tests required more days to be completed, in particular when thermal cycling is involved; however, since the facility is not automated or remote controlled, long duration tests required the presence of operators also during the night. Furthermore, a remote controlled facility will be a valuable aid for teaching, allowing the students to perform long duration experiments and to collect data out of the lesson hours.

At the moment it is possible to access a computer in the facility, referred to as "the server", by using a Virtual Network Computing system (VNC), from any computer or even portable devices with an Internet connection, such as smartphones and tablets, referred to as "the clients". The server is running the software for controlling the turbo-molecular pump and read the pressures, and the acquisition software for recording data from temperature sensors, strain gages and fibre optic sensors (Fig. 9). It is also possible to record pictures from a webcam that can be used to monitor the test from the inspection window on the chamber, for example to verify the orientation of the specimen. The VNC system allows to control the server desktop, to switch on and off the turbo-molecular pump, to record the pressure, to configure and to start and stop data acquisition. The actual configuration was devised having in mind the necessity, for the authorized operators of the lab only, to control the running tests from a remote computer, even from

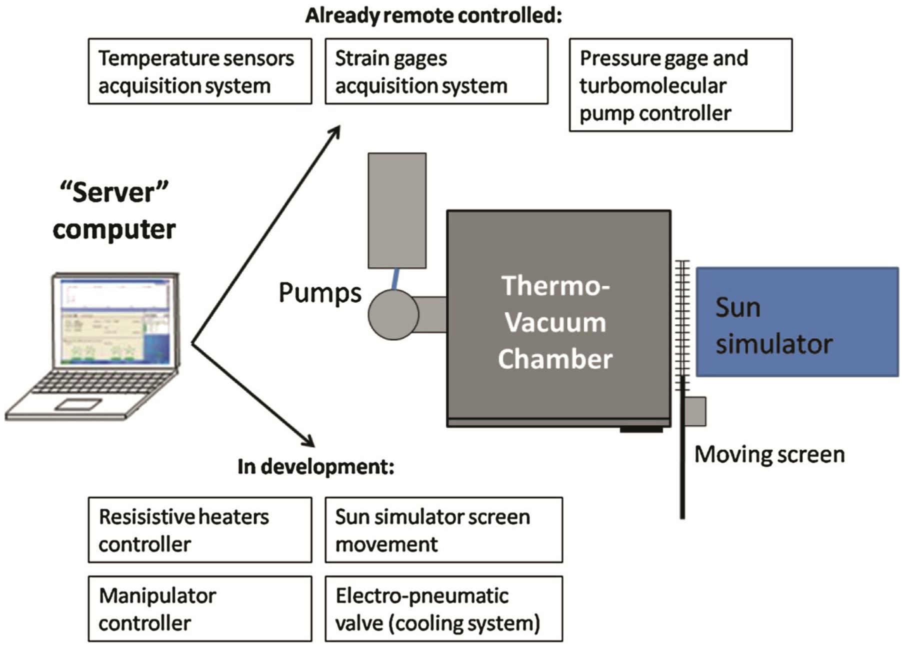

Fig. 10. Scheme of the LARES-lab illustrating the systems already remote controllable and the planned upgrades.

home, in case of long duration tests, and was not intended to be used by students. Indeed, the actual VNC system leaves too much freedom of control over the server PC (i.e. the possibility of deleting files, install or uninstall software) to a remote operator. Moreover, the connection allows only one client at a time to access the server, and there is not a system to manage multiple accesses. We are testing a desktop sharing software for providing multiple accesses to the students using TeamViewer. This software can give the possibility of multiple accesses while controlling the privileges of the clients. A possible scenario for the teacher is to create an on-line meeting with the students for showing an ongoing experiment and giving the possibility to some of them to operate the remote lab under his supervision.

The automation and remote control of the various components involves different levels of difficulties and costs, depending on the chosen implementation. Some components require only a USB connection to the server PC, other will need an external interface (to provide enough power, for example) that will be controlled by the server.

The scheme in Fig. 10 shows which systems are already remote controllable, and which ones are under implementation.

4.1 Manipulator

The manipulator will be upgraded to be controlled by the server and thus by the clients. A stepper motor will be coupled to the manipulator shaft by a drive belt. A controller will be used to interface the server, connected by a USB cable, to the stepper motor in order to control the rotation of the manipulator. The possibility that the motor will introduce unwanted vibrations has been evaluated: in such a case it is possible to install a passive vibration dumper under the manipulator. A similar passive dumper is already mounted under the turbo-molecular pump (Fig. 6).

4.2 Cooling System

The vacuum chamber is already equipped with a liquid nitrogen cooled shroud on five walls, to simulate thermal radiation toward deep space. The shroud can reach a temperature of −190°C using an open cooling circuit: the liquid nitrogen flows through a copper pipe soldered/brazed to the shroud and is then evaporated and dispersed outside the lab. The circuit is fed by a pressurized Dewar. The conversion of the cooling system for remote operation is not a trivial task. The flow shall be controlled by a valve capable to resist to the pressure and the temperature of the liquid nitrogen. The valve shall be operated either by a command of the operator or by an automatic system that reacts at the input from thermometers fixed on the shroud. An automatic controlled valve is intended to avoid wasting too much liquid nitrogen, while maintaining the temperature around the set value, with some oscillations (small variations are allowed since they do not have a significant impact on the test). An automated valve can be either electromechanically operated or electro-pneumatic operated. Electromechanically operated valves use solenoids to develop the magnetic force needed to overcome the elastic force of a spring, hence this kind of valve develops a high peak power and needs a high power to maintain the open position. So to connect the valve to the power line an additional power

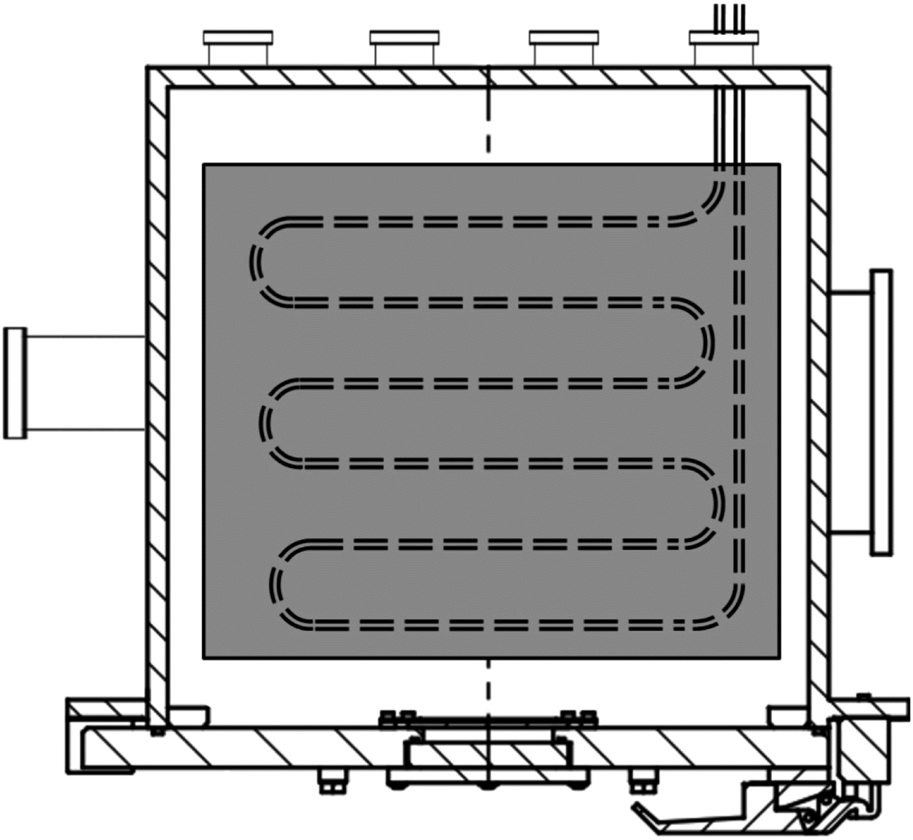

Fig. 11. Scheme of the additional closed-loop cooling system (top view). An aluminum plate, thickness 2.5 cm, is cooled by a copper coil. Inside the coil circulates the refrigerating fluid from an external cooling unit. The pipes of the coils are connected with the external cooling unit via a feedthrough on the back of the chamber.

relay is needed. Electro-pneumatic valves, instead, are operated by a pressurized air circuit and, for our application, are more convenient than electromechanical valves. Indeed, electro-pneumatic actuation allows not only to open and close the liquid nitrogen flux but also to control the flow by partial opening of the valve.

An additional closed-loop cooling system is under development (Fig. 11). With respect to what reported in ref. [30] this second cooling system will allow to reach a temperature of about −50°C sufficient for most tests for LEO environment. Differently from the liquid nitrogen circuit in this case it is used a closed-loop circuit. Also as requested by the ECSS procedures, in this case the heat transfer from the massive metallic heat sink and the test item is mainly obtained through conduction. Aim of those types of tests is to cycle the temperature on the test item in the required range of temperatures. In other words the temperature is imposed on the specimen to prescribed values as a function of time.

4.3 Resistive Heaters

Resistive heaters are used to control the temperature on the items under test or on the disk that simulates the Earth infrared radiation and that has to be maintained at a temperature of −18°C [13]. The experience gained with the testing activities showed that an automatic feedback control, to maintain the specimen temperature stable (i.e. allowing variation of less than 2°C/hour), is not required, once the voltage and the limit current have been manually set on the power unit. The power unit can then be controlled by a software on the computer, allowing remote setting of the heaters.

4.4 Pumps

The thermo-vacuum chamber is equipped with two pumps: the first stage pump (scroll pump) is used to bring the pressure to less than 5 mbar, then the second stage pump can be switched on to obtain a pressure of less than 10^{-5} mbar, as required by ECSS regulations for space environment simulation. Indeed the pressure inside the chamber is typically 10^{-6} mbar, and even less with the liquid nitrogen cooling circuit on.

The turbo-molecular pump can be switched on and off remotely by the control software, provided that the pressure is below 5 mbar.

The scroll pump cannot be controlled remotely and is switched on once the test has been prepared and the vacuum chamber has been closed. The scroll pump is designed to operate continuously for days, to maintain the pressure at a level which is safe for switching on the turbo-molecular pump (i.e. less than 5 mbar). The upgrade foresee the use of an external switch that will allow to operate also the scroll pump remotely. This is a relatively easy task since there is no need of speed or power control.

4.5 Sun Simulator

The sun simulator uses a Xenon arc lamp to simulate solar radiation over a 12 × 12 cm area. The arc lamp requires a dedicated 6 kW power circuit and can be damaged if switched on and off too often, moreover the procedure to switch on the lamp is not straightforward. Therefore the solution to control the Sun simulator, already adopted for the testing activities, is to leave the lamp on and to stop the beam entering the chamber by interposing a removable screen between the lamp and the window. The screen is at the moment moved manually by the operator, but a remote controlled servomechanism is under development. The mechanism will be operated by the computer ("the server") but can of course be controlled also by the clients.

5 Conclusions

LARES-Lab is a thermo-vacuum facility created for the LARES mission, and used to test and qualify satellite components for LARES and other small missions. Also, the facility is used for teaching and didactic activities. At the moment the facility allows remote monitoring of the temperature and pressure sensors and to switch on and off the turbo-molecular pump. A new upgrade concerning a closed-loop cooling system is under design. This will complement the open-loop cryogenic system. The lab is being upgraded to allow remote control of many subsystems, such as the manipulator, the resistive heathers, the Sun simulator and the cooling systems (both open and closed-loop). This way the capabilities of the lab will be improved both for testing and research activities as well as for teaching and e-learning. Remote access to the lab will provide the researchers and the students a way to perform and follow experiments of a certain complexity from the classroom or even from home.

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References

1. Paris, C., Neubert, R.: Tests of LARES and CHAMP cube corner reflectors in simulated space environment. In: 2015 IEEE Aerospace Conference, pp. 1–9 (2015)
2. Ciufolini, I., Pavlis, E.C., Ries, J.C., Koenig, R., Sindoni, G., Paolozzi, A., Neumayer, H.: Phenomenology of the lense-thirring effect in the solar system: measurement of frame-dragging with laser ranged satellites. New Astron. **17**(3), 341–346 (2012)
3. Ciufolini, I., Paolozzi, A., König, R., Pavlis, E.C., Ries, J., Matzner, R., Gurzadyan, V., Penrose, R., Sindoni, G., Paris, C.: Fundamental physics and general relativity with the LARES and LAGEOS satellites. Nucl. Phys. B Proc.Suppl. **243–244**, 180–193 (2013)
4. Ciufolini, I., Pavlis, E.C.: A confirmation of the general relativistic prediction of the Lense-Thirring effect. Nature **431**, 958–960 (2004)
5. Ciufolini, I., Paolozzi, A., Paris, C.: Overview of the LARES Mission: orbit, error analysis and technological aspects. J. Phys: Conf. Ser. **354**, 1–9 (2012)
6. Ciufolini, I., Moreno Monge, B., Paolozzi, A., Koenig, R., Sindoni, G., Michalak, G., Pavlis, E.C.: Monte Carlo simulations of the LARES space experiment to test general relativity and fundamental physics. Class. Quantum Gravity **30**(23), 1–11 (2013)
7. Paolozzi, A., Ciufolini, I.: LARES successfully launched in orbit: satellite and mission description. Acta Astronaut. **91**, 313–321 (2013)
8. Sindoni, G., Paris, C., Paolozzi, A., Ciufolini, I., Pavlis, E.C., Gabrielli, A.: Operation and data analysis of LARES satellite. In: Proceedings of 65th International Astronautical Congress, IAC 2014
9. Ciufolini, I., Paolozzi, A., Pavlis, E.C., Koenig R., Ries J., Gurzadyan, V., Matzner, R., Penrose, R., Sindoni, G., Paris C.: Preliminary orbital analysis of the LARES space experiment. Eur. Phys. J. Plus **130**(7) (2015). (article no. 133)
10. Pavlis, E.C., Ciufolini, I., Paolozzi, A., Paris, C., Sindoni, G.: Quality assessment of LARES satellite ranging data. In: 2nd IEEE International Workshop on Metrology for Aerospace, pp. 1–5 (2015)
11. Persky, M.J.: Review of black surfaces for space-borne infrared systems. Rev. Sci. Instrum. **70**(5), 2193–2217 (1999)
12. European Cooperation for Space Standardization ECSS Secretariat: ECSS-E-10–03A, Space Engineering: testing. ESA-ESTEC Requirements & Standards Division (2002)
13. European Cooperation for Space Standardization ECSS Secretariat: ECSS-E-10-03C, Space Engineering: testing. ESA-ESTEC Requirements & Standards Division (2012)

14. Gilmore, D.G.: Spacecraft Thermal Control Handbook: Fundamental Technologies, vol. I. The Aerospace Press, Menlo Park (2002)
15. Paris, C., Sindoni, G.: LARES-Lab: a facility for environmental testing of satellite components and micro satellites. In: Proceedings of the 2nd IAA conference on dynamics and control of space systems, DyCoSS (2014)
16. Paolozzi, A., Ciufolini, I., Vendittozzi, C.: Engineering and scientific aspects of LARES satellite. Acta Astronaut. **69**, 127–134 (2011)
17. Pearlman, M.R., Degnan, J.J., Bosworth, J.M.: The international laser ranging service. Adv. Space Res. **30**(2), 135–143 (2002)
18. Sindoni, G., Paris, C., Paolozzi, A., Ciufolini, I., Pavlis, E.C., Gabrielli, A.: Operation and data analysis of LARES satellite. In: Proceedings of 65th International Astronautical Congress, IAC (2014)
19. Paolozzi, A., Ciufolini, I., Paris, C., Spano, D., Battaglia, G., Reinhart, N.: Thermal tests on LARES satellite components. In: Proceedings of 63rd International Astronautical Congress, IAC (2012)
20. Paolozzi, A., Ciufolini, I., Paris, C., Sindoni, G., Spano, D.: Qualification tests on the optical retro-reflectors of LARES satellite. In: Proceedings of 63rd International Astronautical Congress, IAC (2012)
21. Paris, C., Parisse, M., Nascetti, A., Cica, R., Salman, N.A.: The TIGRIsat camera. A nanosatellite optical payload for detecting dust and sand storms. In: IEEE 15th International Conference on Environment and Electrical Engineering (EEEIC), pp. 1605–1610 (2015)
22. Nascetti, A.: Satellite system architecture and satellite subsystems. In: Cooperation ARES SWIEE - Rome Meeting (2014)
23. Testani, P., Teofilatto, P., Nascetti, A., Truglio, M.: A nadir-pointing magnetic attitude control system for TigriSat nanosatellite. In Proceedings of 64th International Astronautical Congress, IAC (2013)
24. Paris, C., Parisse, M., Allawi, W.A.: Thermo vacuum tests on TIGRIsat structure. In: 2nd IEEE International Workshop on Metrology for Aerospace, pp 160–165 (2015)
25. Aliane, N.: LABNET: a remote control engineering laboratory. Int. J. Online Eng. **3**(2) (2007)
26. Casini, M., Prattichizzo, D., Vicino, A.: The automatic control Telelab: a remote control engineering laboratory. In: 40th IEEE Conference on Decision and Control, vol.4, pp. 3242 – 3247 (2001)
27. Herrera, O.A., Alves, G.R., Fuller, D., Aldunate, R.G.: Remote lab experiments: opening possibilities for distance learning in engineering fields. In: Kumar, D., Turner, J. (eds.) Education for the 21st Century- Impact of ICT and Digital Resources. IFIP, vol. 210, pp. 321–325. Springer, Heidelberg (2002)
28. May, D., Terkowsky, C., Haertel, T., Pleul, C.: Bringing remote labs and mobile learning together. Int. J. Interact. Mob. Technol **7**(3), 54–62 (2013)
29. Sancristobal, E., Castro, M., Martin, S., Tawkif, M., Pesquera, A., Gil, R., Diaz, G., Peire, J.: Remote labs as learning services in the educational arena. In: IEEE Global Engineering Education Conference (EDUCON), pp. 1189–1194 (2011)
30. Paolozzi, A., Ciufolini, I., Paris, C., Sindoni, G.: LARES-lab: a thermo vacuum facility for research and e-learning. In: 7th International Conference on Computer Supported Education, CSEDU (2015)
31. Cappelletti, C., Martinotti, G., Graziani, F.: UniCubeSat: a test for the gravity gradient solar array boom. In: Proceedings of 62nd International Astronautical Congress, IAC (2011)
32. Graziani, F., Pulcrano, G., Santoni, F., Perelli, M., Battagliere, M.L.: EduSAT: An Italian Space Agency outreach program. In: Proceedings of 60th International Astronautical Congress, IAC (2009)

Supporting Deaf Adult Learners Training in Computer Literacy Classes

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Abstract. While Deaf learners are fluent in a signed language they need to know a written language when acquiring computer literacy skills. We aim to allow Deaf people learn at their own pace and in turn reduce the need to interpret written text. Classroom dynamics and teaching method were studied to extract how lessons were conducted. We then implemented our solution: an authoring tool to structure lesson content and a mobile prototype. The prototype uses South African Sign Language videos arranged according to pre-existing lessons exported by the authoring tool. Results from the user testing showed a reduction in number of representational states which instructions appear in as well as allowing Deaf learners to learn at their own pace.

Keywords: Assistive technology · Authoring tools · Computer assisted instruction · End user application · Mobile applications · Deaf literacy support

1 Introduction

This paper describes our cyclical refinement of a mobile prototype that supports teaching computer literacy skills to Deaf people, using South African Sign Language (SASL) as the medium of instruction. We write Deaf with a capital 'D' to define the Deaf as a cultural group who use a signed language which do not have a written form to communicate much like other groups who use languages like English. Deaf people have limited literacy in spoken and written languages [1]. Acquiring computer skills necessitates pre-existing knowledge of a written language. For Deaf people therefore learning involves simultaneously mastering the written language whilst learning computer skills and technical terminology.

Our previous SignSupport projects aimed at bridging communication between Deaf and hearing people. The projects focused on constrained contexts where a limited collection of interactions were incorporated into pre-recorded SASL videos. The interactions previously investigated were between a doctor

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and a Deaf patient [2] and between a pharmacist and Deaf patients, [3] implemented on a mobile phone [4]. We are extending this to a different communication context.

In this paper, we explore the context of adult computer literacy training. We investigate how to support Deaf people learning computer literacy skills using the e-learner training system [5], an International Computer Driving License (ICDL www.icdl.org.za) approved curriculum, developed by Computers 4 Kids (www.computers4kids.co.za). At present, teaching Deaf learners involves the teacher interpreting the lesson content from the e-learner manual into SASL. In the process, all Deaf learners must look at the teacher due to the visual nature of signed language. Progress of faster learners is impeded since the pace of the class is dictated by the weaker learners because when something is unclear, all have to be interrupted. We also investigated whether mobile devices were a viable means to support Deaf learners because of their ubiquitous nature.

Deaf people's text literacy is adequate for social purposes between Deaf people who accept grammatical problems but often not for technical discussion [6]. Consequently, it creates a communication barrier which hinders Deaf people from acquiring new skills and limits them from seeking higher education and employment opportunities. Many are unemployed or employed in menial jobs. The socio-economic level of the community is affected as a whole [7]. We partnered with a grassroots NGO, Deaf Community of Cape Town (DCCT) which is staffed primarily by Deaf people and serves the needs of the larger Deaf community.

We conducted a field study and two user studies, in three research cycles, with Deaf DCCT staff members as participants to investigate how mobile phones could be used to support Deaf learners acquiring computer literacy skills. The field study sought to investigate the obstacles that Deaf learners encounter while acquiring computer skills and establish the existing technology capacity of the Deaf community. From the results we obtained, we designed and implemented our intervention, addressing some of the issues identified in the field study and evaluated the developed solution with our participants.

2 Related Work

We describe work related to SignSupport here, examining Deaf literacy practices and the work of others in the area of computer literacy projects with Deaf people.

2.1 Deaf Adult Literacy

Internationally and in South Africa, development of literacy in Deaf adult population has had its challenges. Internationally, the average reading age of Deaf adults is said to be at fourth grade level [8] and in South Africa, the average reading age of Deaf adults who have attended schools for the Deaf is lower than the international average [9]. Apartheid further caused racial inequalities in educational development and provision resulting in varying literacy levels in Deaf people across different racial groups [10].

In the *Bilingual-Bicultural* approach, Deaf learners are taught through a signed language to read and write the written form of a spoken language [11], there being no accepted written version of the signed language. Previous approaches to Deaf literacy such as the principle of Oralism [12] and total communication [13], neglected the need for Deaf people to learn in their own language and promoted little literacy development. Research has shown that Deaf learners taught in sign language perform better than learners who are not [14]. Glaser and Lorenzo [1] provide an approach that aims to redress low literacy levels among Deaf adults in South Africa where the use of the Deaf learners' existing knowledge of SASL and written English. It highlights the difference between these two languages in order to facilitate the development of their second-language skills in written English. For Deaf learners, literacy is moving from a primary to a secondary communication form as well as moving from one language to another. We adopt the bilingual-bicultural approach to teaching computer literacy skills. By teaching the lessons in SASL, we use the Deaf learners existing knowledge (the known), to introduce computer literacy skills (the unknown).

2.2 Computer Literacy Projects

There are numerous projects that have sought to address increasing the educational level of Deaf and hard-of-hearing persons. In order to meet users' needs, in addition to providing guidelines based on technology, it is necessary to understand the users and how they work with their tools [15]. One approach provides additional educational input using multimedia-supported materials on the World Wide Web [16]. This kind of user interfaces can be found in other projects such as BITEMA [17] and DELFE [18]. Results from these projects have shown that multimedia systems additionally increased the success of learning.

Project DISNET in Slovenia [16], focused on providing an alternative way of learning computer literacy using accessible and adapted e-learning materials. It used multimedia materials in a web-based virtual learning environment. The project aimed to increase computer literacy among Deaf and hard of hearing unemployed people using the ICDL e-learning material [16]. The system was designed for people who have access to computers, high speed broadband Internet but without basic computer or web browser experience.

The above projects focus on e-learning materials and e-learning environments with dependence on the World Wide Web to distribute their multimedia materials. The commonality between our work with the projects above is the use of multimedia learning materials.

2.3 Discussion

SignSupport emphasizes video quality and resolution [19]. The videos are stored locally on the phone. High data costs in South Africa compared to neighbouring African countries [20], make it uneconomical for already marginalised Deaf people to access remotely stored data. Similar to project DISNET, we utilise multimedia ICDL learning materials to improve computer literacy education levels amongst Deaf people. It differs by not being web-based and not using broadband internet connections; SignSupport is mobile-based and uses commercially available devices.

3 Methodology

SignSupport was based on over a decade of research and collaboration by an interdisciplinary team comprising a diverse range of expertise. All members were involved continuously through the project [7].

Deaf users played the steering role in the research. They dictated how they would used it and most of the user requirements were gathered from them by integrating their perspectives thereby increased chances of an accepted solution.

A Deaf education specialist who was the link between the technical team and the Deaf community members in addition to being the facilitator for the computer literacy course. The specialist assisted in design and explanation of Deaf learning practices to make SignSupport fit Deaf users' expectations and helped translate the course material into SASL.

Computer scientists who were tasked with implementing the design of SignSupport and verified that the SASL videos were displayed in the correct and logical order. They examined how end users engaged with SignSupport to uncover design flaws and any other interesting outcomes.

We undertook a community based co-design process [7,21] following an action research methodology. This approach required participation with the target groups and engaged them throughout the design, implementation and evaluation phases and referred back to them to show how their feedback is incorporated into SignSupport. During interactions with Deaf participants, the facilitator who is acceptably fluent in SASL facilitated the communication process which aided us in understanding the usage context and building positive relationships with the Deaf community.

We undertook three research cycles. In the first cycle we observed and participated in the computer literacy classes at DCCT where some of their staff members were taking the classes and conducted unstructured interviews with the facilitator in the form of informal conversations and anecdotal comments made by the facilitator during the class sessions. Data were gathered using hand written notes, video and photographs were used to build a cognitive system [22] of the computer literacy classes following a distributed cognition approach. The ideas generated were then used to synthesize our solution intervention. The second cycle we implemented our solution and evaluated it. The feedback we received in the second cycle was used as input to the third cycle to refine our solution.

We collaborated with two other researchers to co-design an XML specification that was used to structure lesson content and generated by a content authoring tool. The XML specification was an abstraction of the hierarchical structure of the e-learner manual. A mobile prototype was developed that used the XML specification and mapped the content of the e-learner and serially displayed the content in SASL videos and images. The mobile interface design was inspired by the work of Mothlabi [4] such that the video frame size covered at least 70 % of the display size and the navigation buttons and image filled up the rest of the space.

We recorded SASL videos of two lessons chosen from the e-learner curriculum using scripts that we created and videos that were stored on the mobile phone's internal memory. The mobile prototype was then evaluated in a live class setting and the results were taken into account for the next design in the third cycle.

4 Computer Literacy Classes

The computer literacy classes (e-learner classes henceforth) are taught using the International Computer Driving license (ICDL) approved curriculum, e-Learner [5], which has two versions: school and adult of which the latter is taught at DCCT. The classes aim to equip Deaf learners with computer skills that will result in the learners taking assessments to obtain the e-Learner certificate. The Deaf learners then progress to the full ICDL programme. These classes are taught by a facilitator and co-author, Meryl Glaser, who has been in a long involvement with DCCT in addition to collaborating with researchers from the University of Cape Town (UCT) and the University of the Western Cape (UWC) in the SignSupport project.

All the Deaf learners were DCCT staff members. Three were female and two were male with an average age of 38.4 years. Prior to the beginning of the e-learner classes, three of the learners had received the EqualSkills certificate [23]. EqualSkills – also an ICDL programme – provides flexible learning programme that introduces basic computer skills to people with no prior exposure.

4.1 Course and Lesson Structure

E-learner is a modular and progressive curriculum spread over seven units which are: IT Basics, Files and folders, Drawing, Word processing, Presentations, Spreadsheets and Web and Email essentials. The units are similar to the modules in the ICDL programme but contain simplified content. The e-learner curriculum is in two parts: a manual containing lesson instructions used by the facilitator and software, loaded on to the computers that the Deaf learners use to retrieve templates and lesson resources. The Deaf learners use computer applications to complete the templates following signed instructions from the facilitator. The facilitator first teaches literacy skills in the written language to develop their technical vocabulary.

These units are composed of lessons that have the same structure in the following categories: Orientation, Essential and Supplementary. Lessons in different units overlap i.e. the same lesson appears in different units. This allows for the learner to revise a lesson or skip it having done it before. The lesson structure is as follows:

1. Integrated activity – A class discussion on the lesson content.
2. Task description – A brief overview of the work the learners will perform.

3. Task steps – The list tasks that the learners perform to complete the lesson.
4. Final output – A diagram showing what the learners are expected to produce after performing the task steps.

4.2 Classroom Setup

In the computer lab there are six computers in a U-shaped arrangement. There is a server at the front left of the classroom with a flip-board on a stand and two white boards. The arrangement is to allow the learners to have a clear line-of-sight to view the front of the classroom where the facilitator stands and signs. The seating arrangement also allows the Deaf learners to see each other which is crucial for class discussions and to see contributions from other learners and questions.

Each computer, except for the server, is running a copy of Microsoft Windows 7. All computers have a copy of Microsoft Office 2007 and e-Learner Adult version 1.3.

4.3 Results

In observation and participation in the e-Learner classes we uncovered various themes that are discussed below.

Although the lessons in the e-Learner manual had the same structure, the facilitator adapted the teaching method and lesson content to make it relevant for the Deaf learners. Teaching generally takes up a whole lesson and the Deaf learners only get to perform the tasks in the next class session on the following week.

Images played an important role in teaching. There were numerous times where the facilitator pointed at a projected image of the computer application that was being used in the lesson, pointing out buttons and icons and lists to scroll through.

Teaching the Deaf learners is demanding and tiring for the facilitator. There is one copy of the e-Learner manual used for the lessons because the Deaf learners are text illiterate, unable to read the English text in the manual. The facilitator has to read the instructions, understand them before signing the instructions to the Deaf learners in SASL. In other instances, the facilitator has an assistant who voices the instructions to the facilitator who then signs them to the Deaf learners.

The facilitator has to gain the undivided visual attention of the learners. This is a necessary step in order to explain a concept or provide instructions to the Deaf learners due to the visual nature of sign language. This distinguishing factor between Deaf and hearing learners is called divided attention. Hearing learners can simultaneously listen to instructions being provided while they look at their computer monitors. Deaf learners cannot watch the SASL signing and look at their computer screens at the same time. Eye contact first has to be established before signing can begin.

Deaf learners use SASL as their principal language of communication and it has its own structure and vocabulary. English users bring all the necessary vocabulary to the task of computer literacy skills learning. Deaf learners lack this vocabulary to rely on, hence they are learning English vocabulary and ICT skills concurrently. For example, in a lesson observed, the facilitator broke down the word "duplicate" into the phrase "make a copy" after which the Deaf learners associated copy with its respective sign in SASL. English vocabulary in computer literacy classes has to be simplified by either making use of synonyms, definitions or descriptions.

We observed different individual work rates of the Deaf learners during our class participation, similar to hearing learners. The difference is that Deaf learners have the additional burden of having to stop and look at the facilitator for instruction. All need to be interrupted to see signed instruction. This would interrupt the whole class and the learners work rate. The faster learners usually finished their tasks earlier and often spent time waiting for the slower learners to catch up. As a result, the pace of learning was dictated by the slower learners because facilitator was forced to teach at a slower pace to accommodate the slower learners. This puts pressure on the slower learners and makes it boring and at times frustrating for the faster learners. The faster learners were the same three Deaf learners, previously identified, who had acquired EqualSkills certificates.

We also observed the Deaf learners using various mobile phones. These phones ranged from feature phones to smartphones. One learner had two smartphones: a HTC running Android OS for work and a Blackberry for personal use. Two other participants had Nokia feature phones with QWERTY keyboards. These devices are capable of playing video as well as instant messaging applications such as WhatsApp. In addition, the Deaf learners do not have computers or laptops at home and at work, they use old computers hence their limited experience.

4.4 Analysis and Design Implications

We use a distributed cognition approach [24, p. 91] to understand the e-learner class environment. Distributed cognition studies the cognitive phenomena across individuals, artefacts and internal and external representations in a cognitive system [22] which entails:

- Interactions among people (communication pathways).
- The artefacts they use.
- The environment they work in.

We define our cognitive system as the e-learner class where the top-level goal is to teach computer skills to Deaf learners. In this cognitive system we describe the interactions in terms of how information is propagated through different media. Information is represented and re-represented as it moves across individuals and through an array of artefacts used (e.g. books, written word, sign language) during activities [24, p. 92].

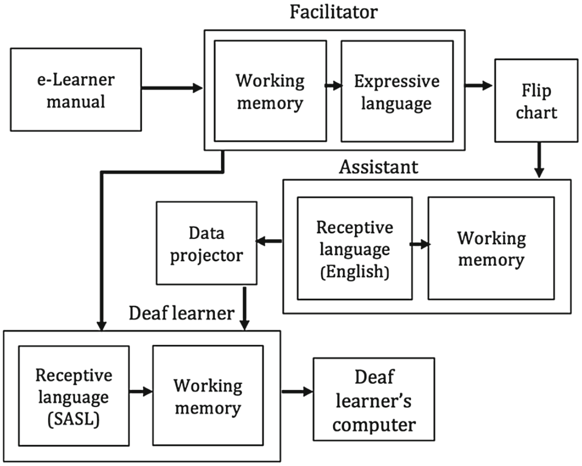

Fig. 1. A diagram showing the propagation of representational states for the teaching method to deliver a single instruction to the Deaf learners. The boxes show the different representational states for different media and the arrows show the transformations.

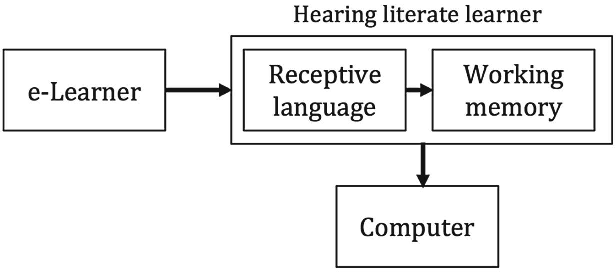

Fig. 2. The diagram shows the propagation of representational states for a hearing literate person. The boxes show the different representational states for different media and the arrows show the transformations.

Propagation of representational states defines how information is transformed across different media. Media here refers to external artefacts (paper notes, maps, drawings) or internal representations (human memory). These can be socially mediated (passing a message verbally or in sign language) or technologically mediated (pressing a key on a computer) or mentally mediated (reading the time on a clock) [24, p. 303]. Using these terms we represent the computer literacy class cognitive system showing the propagation or representative states for the teaching methods.

By representing the teaching method in the diagram (see Fig. 1) we discover the task of teaching Deaf learners involves a set of complex steps. Instructions are propagated through multiple representational states, verbally when interacting with the assistant, visually when interacting with the Deaf learners and mentally in both cases. In comparison with the situation for hearing learners (Fig. 2) the representational states are fewer. Our proposed system attempts to bring the Deaf learners closer to how hearing literate people learn.

The design implications were to reduce the number of steps involved to deliver instructions to the Deaf learners. Our solution was to deliver the lesson instruction in SASL videos and images, effectively removing a number of representational states, approximately four. These SASL videos were pre-recorded and contained the lesson instructions from the e-learner manual thereby eliminated the need for the assistant and the facilitator to deliver the lesson instructions. In addition, the limited text literacy amongst the Deaf learners meant the need for SASL instructions to allow them to learn in their preferred language.

Mobile phones provided an ideal way to deliver the lesson content and most Deaf people used a mobile phone to communicate with other Deaf and hearing people [3]. This solution made use of off-the-shelf mobile phones similar to the previous SignSupport solution. Therefore, SignSupport could be carried home by Deaf learners on their cellphones and teach themselves where access to a computer was available. In addition, the socio-economic situation of the Deaf learners put them in a position unable to afford the high data costs. This eliminated the use of data networks to host lesson content remotely in order to stream to the mobile phones.

Another design consideration was to organise and structure the SASL videos to represent the logical flow of the lessons in the e-learner. It involved design of a data structure that effectively structured the course and lessons to reflect the e-learner manual. Discussion of the design is in the following section.

5 Design and Implementation

In this section we discuss the technical details of the design of the data structure, the design of the content authoring tool and the user interface of the SignSupport mobile prototype.

5.1 Structuring Lesson Content

To make the SASL videos and images meaningful, they need to be organized in a logical manner that reflects the e-learner lesson structure (see Sect. 4.1). In our analysis of the e-learner classes, we revealed the numerous steps involved to deliver lesson content to Deaf learners. To model the structure of the e-learner curriculum we chose Extensible Markup Language (XML) [25] as our data format. XML provided the necessary flexibility to represent the curriculum in its hierarchical structure. To manage the lesson resources (SASL videos and images) we chose to use Universal Resource Locators (URLs) that would point to the location where the resource was stored.

We abstracted the e-learner hierarchical structure representing the course, unit and lesson with unique identifiers. Lessons were further classified by category: Orientation, Essential and Supplementary. The resulting XML structure is shown in Fig. 3.

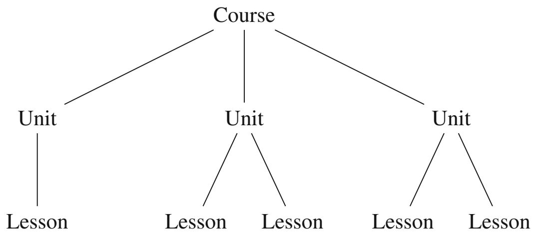

Fig. 3. The XML structure of the course.

The e-learner curriculum changed infrequently making it beneficial to store the resources locally on the device. This effectively make the system independent of data networks to update the lesson content. In order to manage the lesson assets and the XML lesson files effectively we decided to store all in the folder structure.

This XML data structure is parsed using built-in XML parsers used by the mobile prototype (see Sect. 5.3).

5.2 Content Authoring Tool

We needed to design a content authoring tool to run on a computer that would structure the lesson content. It would allow domain specialists such as the facilitator to create content for their usage context without the need for a programmer. Mutemwa and Tucker identified the lack of this as a bottleneck to their SignSupport designs [2], limiting their design to one scenario within the communication context.

The design was modelled on the structure of the e-learner manual (see Sect. 4.1). It uses drag-and-drop features to add lesson resources (videos and images) to the placeholder squares that represented the lesson description, task description and task step as shown in Fig. 4. Lesson resources are uploaded to the authoring tool and displayed in panels on the right. Once a lesson is created and lesson resources added, it can be previewed to view the lesson in sequential order from the beginning. The lesson is then added to a unit and a course before saving and exporting the course. Exporting the course generates the XML data structure that then consumed by the mobile prototype below (see Sect. 5.3).

The authoring tool was implemented using Java FX [26] using Netbeans 7.4 integrated development environment (IDE). It was tested on both Microsoft Windows 7 and Apple Mac OS X 10.9.5 to check for compatibility.

5.3 Mobile Prototype

The mobile phones we used had 25 gigabytes (GB) of internal storage space, with a touch sensitive display of size 4.8 inches and a resolution of 1280 by 720 pixels. The phones run Android OS 4.3 (Jelly bean). The higher resolution screen was

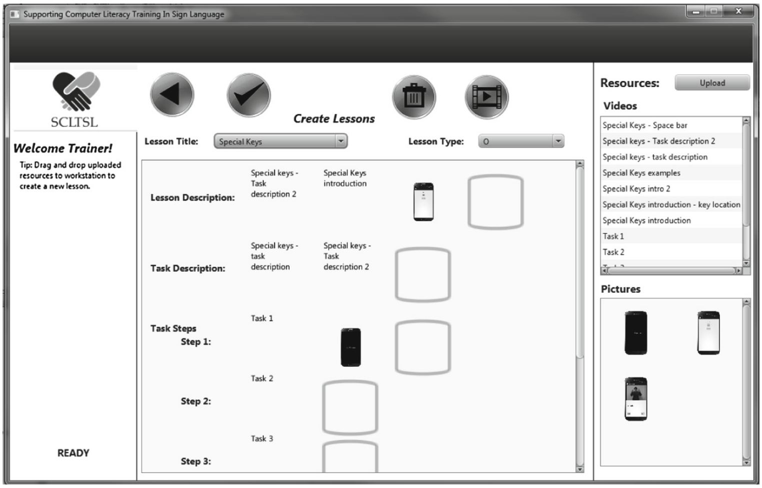

Fig. 4. The content authoring tool interface that allows the facilitator to create lessons for Deaf learners.

considerably larger in comparison to the display used in the previous version of SignSupport [4]. Our version of SignSupport was only similar in video playback interfaces but differed in content structure and context of use. The extra space allowed for an image to be inserted below the video frame in addition to the navigation buttons (see Fig. 5).

Navigating the mobile prototype interfaces is performed in two ways: linear and hierarchical navigation. For linear navigation, a Deaf learner uses the next and back buttons on the lesson detail screen (see Fig. 5) to move between video instructions. The linear structure navigates through the XML structure (see Sect. 5.1) that was generated from the content authoring tool (see Sect. 5.2). Hierarchical navigation is done moving from the home screen down to the lesson detail screen and back shown in Fig. 6. To navigate down to the lesson detail screen, the Deaf user starts on the home screen and selects a lesson from the list of lessons (see Fig. 7) by pressing on the list item that has the lesson name. Once a lesson is selected, the Deaf learner is presented with another list of lesson sections where the learner clicks on a list item to reveal the screen shown in Fig. 5 that contains the SASL video instructions. For better user experience, the depth of the hierarchical navigation was at most two levels from the home screen.

XML data is parsed In the backend of the mobile prototype, the XML data format designed in Sect. 5.1 was parsed using the Android interface *XmlPullParser*. XML files stored in the SignSupport folder in the mobile phone internal memory are modelled using an ArrayList data structure. Navigation is facilitated using clickable list widgets and buttons on the interface and scrolling through the list of lessons and lesson sections (see Fig. 7) was done through swipe gestures.

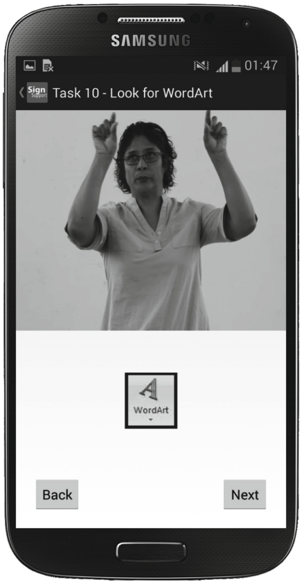

Fig. 5. The SignSupport interface with an image of an icon beneath the video and video caption in the action bar which indicates the instruction the learner is currently working on.

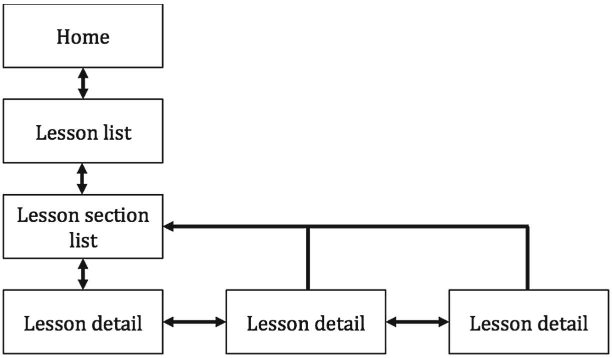

Fig. 6. User interface navigation on the mobile prototype of SignSupport. The boxes represent the different screens the user interacts with and the arrows indicate the direction of navigation between the screens.

The mobile prototype is designed to be used concurrently with a computer as a tutoring system. The Deaf learner can query the facilitator if further clarification is needed and when in the presence of a facilitator.

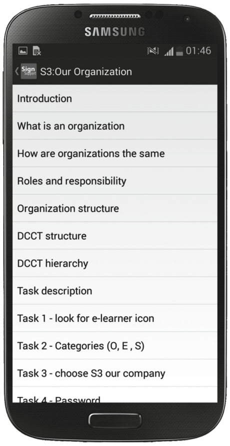

Fig. 7. User interface navigation on the mobile prototype of SignSupport. The interface shows the lesson sections in a scrollable list. The Deaf learner taps on the desired list item to reveal the screen with the SASL video instructions.

6 Content Creation

6.1 Recording Procedure 1

We recorded SASL videos with the help of a professional SASL interpreter who met the following criteria: A registered SASL interpreter and a background in education.

Before recording the videos, we created conversation scripts for two lessons we selected from the e-learner manual on the basis of difficulty. We first wrote down the original instructions of the lesson. Afterwards, the facilitator guided us with the abstraction of the lesson content putting emphasis on the resulting instructions must have one task or a single explanation per bullet point. Multiple instructions were further broken down to single tasks and single explanations and computer terminology explained in detail. In some cases synonyms for complex terms were used instead. For example the word *duplicate* was replaced with the phrase "copy and paste" where signs their existed in SASL. These steps were repeated until all instructions were done and simplified.

The recording procedure involved instructions on a conversation script being voiced to the interpreter. The interpreter then signed on camera until all the instructions on the script were translated into SASL. Signed instructions were separated by writing down the number of the instruction on a whiteboard or paper according to its position on the script and displaying it in-front of the camera while continuously recording. When the interpreter put her hands down, that was the visual cue that the signing for that particular instruction had ended and helped us when editing the SASL videos.

The recorded SASL videos were edited in Adobe Premier Pro CS6 where the audio channel was removed to reduce video file size. The resulting videos were encoded using the H.264 video codec with a frame size of 640 × 480 pixels and a frame rate of 25 frames per second (fps) as per the ITU requirements [27]. The final video had MPEG-4 video compression that was compatible with Android OS and the official video format for the platform. The resulting video clips are short, the longest video clip is 48 seconds which does not pose a high cognitive workload on the learner.

6.2 Recording Procedure 2

In this recording procedure we hired a SASL interpreter who had previously worked with DCCT and was known by the community. This ensured that the dialectal differences that were identified in Sect. 7.1 were avoided. We chose the lesson "S3: Our Organisation" from the e-learner manual. A conversation script was generated but the lesson content was tailored to suit the Deaf learners. The lesson instructed the learners to create a chart for their own organization, DCCT.

Recording of the SASL videos was done at the DCCT premises during office hours. Present at the recording were the interpreter, facilitator and an advanced Deaf learner. The recording setup was as follows: Two cameras on two tripods, positioned in-front of the interpreter to ensure redundancy in case of failure of a camera. The Deaf learner and facilitator stood off camera view with a laptop running Microsoft Windows.

Instructions were voiced from a conversation script to the interpreter. The Deaf learner watched the interpreter's signing to check if the signing was correct. If the correct sign for computer terminology was not used, the Deaf learner corrects them and the video was re-recorded. Instructions that needed clarification in terms of the position of the Microsoft Word tools, all three parties would pause the recording and refer to the laptop with Microsoft Word. Only then was the instruction re-recorded. These steps, not all, were repeated until all instructions on the conversation script were recorded. Additional short video clips for contextual information and discourse markers (videos to inform the learner to progress forward or go back to the previous instruction) were recorded.

The videos were recorded with a resolution of 1920 by 1080 pixels at 25 frames per second. They were edited similar to Sect. 6.1 following the same procedure and only changing the colour channel to grayscale to further reduce the file size [4]. The resulting video clips are short, the longest being 48 seconds. The total number of clips for the lesson were 51 videos: 7 lesson description videos, 1 task description video and 43 task step videos.

7 Cycle 1

The above design of the prototype is evaluated using the lesson content recorded in Sect. 6.1. The XML files parsed by the prototype in this cycle are hand coded and not exported lessons generated by the authoring tool.

7.1 Evaluation

This section analyses the results obtained from our user evaluation of the mobile prototype. We observed the Deaf learners to uncover design flaws and any other interesting use of the prototype.

Procedure: Five DCCT staff members participated in the evaluation. These were the same Deaf learners identified in Sect. 4. The facilitator was present to interpret on our behalf. The Deaf participants were each given a smart phone that contained the prototype. After a short briefing about the project, the Deaf participants were first trained how to use the system then given a practice lesson to do for 20 min to get a feel of using the prototype and a second lesson to do for 30 min. In the first lesson, the learners were required to pair graphics of special keyboard keys (e.g. Space bar, Shift key etc.) with images that represent their function. The second lesson required the learners to identify and name different storage media. Then, identify which files represented by icons could fit into the storage media without exceeding their capacities. Both lessons were provided in Microsoft Excel templates. After, the Deaf participants were invited to participate in a focus group discussion to get their opinions and feedback on the prototype. The session was video recorded and photographs were taken with the help of an assistant.

Questionnaires were not used to elicit feedback on the system. Motlhabi noted that conducting an evaluation with Deaf text semi-literate participants proved to be a problem while answering questionnaires [4]. Interpreters were scarce and costly to hire and the number he hired were not enough to interpret the questionnaires for each participant individually without very long delays for the participants.

7.2 Results and Analysis

The number of representational states involved in delivering a single instruction were reduced by 4. It eliminated the facilitator, flip chart, data projector and assistant states involved in the process shown in Fig. 8. The reduction in representational states moved the Deaf participants closer to hearing literate users with the same number of representational states (see Fig. 2).

The participants had little difficulty navigating the user interface. Two participants had difficulty locating the back button on the interface that navigated back to the list of lesson sections even after training. All the participants managed to re-watch the SASL videos. It was easy for them to employ a tap on the video frame to bring up the video controls to replay the video. They also found it easy to navigate through the lesson content using the back and next buttons on the interface as well as navigate between the list of lesson sections and the lesson detail screen that contained the SASL videos.

All the participants noted that some signs used in the videos were different to theirs, indicating dialectal difference in the signs used in the SASL videos. Despite the difference, the stronger participants were able to understand the

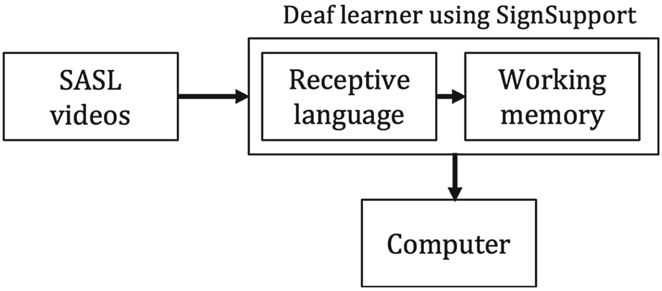

Fig. 8. The representational states of a single instruction being delivered to a Deaf learner using SignSupport. The reduced states make it simpler for Deaf learners and promotes individual work.

context of the instructions and continue with the tasks. In this case these stronger participants helped the weaker participants understand the instructions in 18 instances observed.

We also observed, during the testing, that the Deaf participants were individually working at their own pace, and the facilitator helped the participants individually in 21 different instances. Two of the 21 instances of assistances were initiated by the Deaf participants while the other 19 were initiated by the facilitator. In 9 out of the same 21 instances, the facilitator prompted a Deaf participant to continue with the task, click on a button or replay a video. In the other 12 instances, the facilitator explained unclear instructions in SASL. The assistance did not affect the other participants working individually and the role of the facilitator changed from delivering the lesson content to a support role. Consequently, the workload on the facilitator is reduced.

Some Deaf participants noted a mismatch between the instruction and what they expected to see on the computer. The mismatch occurred due to unforeseen steps such as the monthly password that is entered in the software to access the lesson content. The facilitator reported that additional SASL videos with contextual information and discourse markers [28] were needed to provide cues for the Deaf participants to progress to the next instruction or to perform a task.

8 Cycle 2

In this cycle we took the feedback from the results from the previous evaluation in Sect. 7.1, particularly the instruction inconsistencies and re-recorded sign language videos in Sect. 6.2. The lesson content used here was generated and exported by the authoring tool.

8.1 Evaluation

We evaluated the mobile prototype after re-recording the videos in Sect. 6.2.

Procedure. Four Deaf participants were used in the evaluation. Three participated in the previous evaluation in Sect. 7.1 and one was new to the project. Two participants were advanced learner, one intermediate and the last a beginner. Also present, an advanced Deaf learner who assisted in the filming of the SASL videos (see Sect. 6.2) and acted as an assistant, the facilitator and the research team. The facilitator and assistant were only there to clarify SASL instructions. Additionally, the facilitator interpreted on our behalf. Much of our procedure was similar to in Sect. 7.1 with the only difference of the lesson content focused on organization charts. Data was collected using note taking, photographs and video recording. Observations and comments made by both the facilitator and Deaf learners were recorded on video for later analysis.

8.2 Results and Analysis

While still achieving the same representational states as in Sect. 7.2, the fastest learner (participant 3) completed the lesson in 1 h 6 min. In that same period, Table 1 below shows the number of completed tasks. The tasks correspond to the task step videos that the learners had to perform in order to create an organization chart.

Table 1. Task completion rates of the lesson by the Deaf participants.

Participant	Tasks completed	Total
1 (intermediate)	29	72.5 %
2 (advanced)	31	76.5 %
3 (advanced)	43	100 %
4 (beginner)	23	60.8 %

From Table 1 we see the that the beginner learner (participant 4) had the lowest completion rate. We observed that the learner needed more help compared to the other participants. The learner required prompting to carry on. In another observed instance, the same participant was staring at a dialog box where she had to click *Ok* button for the dialog box to disappear. In another instance the same learner sought assistance from the facilitator to confirm whether the SmartArt object chosen was the correct one. From these observations and task completion rates, the difference in computer literacy between advanced learners and the beginner learner is evident. This allowed the assistant or facilitator to focus on assisting the beginner (participant 4) while the advanced learners (participant 2 and 3) continued with their individual work. From these results, we reconsidered the target group for SignSupport to be more suited to the Deaf learners with some basic exposure to computer literacy, shown by the individual work rates of the advanced learners.

The facilitator engaged with the participants in 25 observed instances compared to 28 instances that the assistant engaged with the same participant. The facilitator clarified instructions that were potentially confusing to an advanced learner (participant 2) or to prompt the other learners. In addition, the facilitator instructed the assistant to help the learners with problematic spelling, for example the word *organization*. In the assistant's engagement, the assistant prompted the participants to clarify some of the SASL instructions that the participants misinterpreted. In the event that the assistant was not sure of an instruction, the facilitator was called in to assist.

The assistant's presence proved to be helpful in reducing facilitator workload. The assistant helped participants with terminologies and unfamiliar signs used in new terminology that was developed in the class. Workload reduction was shown by the 28 instances of assistant engagement compared to the 25 instances of facilitator engagement. It allowed the facilitator to step back and allow the assistant run the session demonstrating signs of sustainability of SignSupport.

We observed the emergence of a blended learning environment. Lesson content provided electronically through SignSupport while instructors (assistant and facilitator) were present. This environment allowed the facilitator to engage more with the learners and assistant rather than deliver content.

9 Conclusion and Future Work

SignSupport suited Deaf learners with prior exposure to computer literacy skills which benefits them learning in their preferred language, SASL. In our discussion, we discovered the obstacles that text illiterate Deaf people encountered while acquiring computer skills dependent on the facilitator using one copy of the e-learner manual. Distributed cognition revealed the number of representational states involved in delivering a single instruction to Deaf learners and the cognitive overhead on the facilitator while teaching.

We designed and implemented a prototype on commercially available devices, which showed potential to support Deaf users acquiring computer literacy skills by presenting content in SASL videos. We observed the prototype allowing the Deaf users to work individually at their own pace, with or without the assistance from the facilitator or assistant. Thereby reducing the workload on the facilitator. The decreased number of representational states decreased the cognitive overhead on the facilitator. Furthermore, SignSupport has demonstrated to work effectively in a blended learning environment with an assistant (Deaf learner) taking a more active role in teaching allowing the facilitator to step back.

Our design of an XML data format to represent lesson content, organised the SASL videos and images logically. The findings from this work are being used to generalise to other Deaf users undertaking computer literacy training.

Future work could investigate whether the SignSupport effectively increases computer literacy skills among Deaf people. This would involve a pedagogy study with Deaf learners with pre-existing basic computer knowledge and also see if the assistant can replace the facilitator.

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References

1. Glaser, M., Lorenzo, T.: Developing literacy with Deaf adults. In: Disability and Social Change: A South African Context, pp. 192–205 (2007)
2. Mutemwa, M., Tucker, W.D.: A mobile Deaf-to-hearing communication aid for medicaldiagnosis. In: Southern African Telecommunication Networks and Applications Conference (SATNAC), Stellenbosch, South Africa, Telkom, pp. 379–384 (2010)
3. Chininthorn, P., Glaser, M., Freudenthal, A., Tucker, W.D.: Mobile communication tools for a South African Deaf patient in a pharmacy context. In: Information Society Technologies-Africa (IST-Africa), pp. 1–8. IIMC International Information Management Corporation, Dar es Salaam, Tanzania (2012)
4. Motlhabi, M., Glaser, M., Parker, M., Tucker, W.: SignSupport: a limited communication domain mobile aid for a Deaf patient at the pharmacy. In: Southern African Telecommunication Networks and Applications Conference (SATNAC), Stellenbosch, South Africa (2013)
5. e-Learner: e-Learner - a modular course of progressive ICT skills (2013)
6. Glaser, M., Tucker, W.D.: Telecommunications bridging between Deaf and hearing users in South Africa. In: Conference and Workshop on Assistive Technologies for Vision and Hearing Impairment (CVHI) (2004)
7. Blake, E.H., Tucker, W.D., Glaser, M.: Towards communication and information access for Deaf people. S. Afr. Comput. J. **54**, 10–19 (2014)
8. Watson, L.M.: Literacy and deafness: the challenge continues. Deafness Educ. Int. **1**, 96–107 (1999)
9. Aarons, D., Reynolds, L.: South African Sign Language: changing policies and practice. In: Many Ways to be Deaf: International Variation in Deaf Communities, p. 194 (2003)
10. Penn, C.: How do you sign 'apartheid'? The politics of South African Sign Language. Lang. Probl. Lang. Plann. **14**, 91–103 (1990)
11. Grosjean, F.: The Bilingual and the bicultural person in the hearing and in the Deaf world. Sign Lang. Stud. **1992**, 307–320 (1077)
12. Lane, H.L.: The Mask of Benevolence: Disabling the Deaf Community. Vintage Books, New York (1993)
13. Denton, D.M., British Deaf Association: The Philosophy of Total Communication. British Deaf Association (1976)
14. Prinz, P.M., Strong, M.: ASL proficiency and English literacy within a bilingual deaf education model of instruction. Top. Lang. Disord. **18**, 47 (1998)
15. Theofanos, M.F., Redish, J.G.: Bridging the gap: between accessibility and usability. Interactions **10**, 36–51 (2003)
16. Debevc, M., Povalej, P., Verlic, M., Stjepanovic, Z.: Exploring usability and accessibility of an e-learning system for improving computer literacy. In: International Conference in Information Technology and Accessibility, Hammamet, Tunisia (2007)

17. Debevc, M., Zoric-Venuti, M., Peljhan, V.: E-learning material planning and preparation. Report of the European Project BITEMA (Bilingual Teaching Material For The Deaf byMeans of ICT) (2003)
18. Drigas, A.S., Kouremenos, D., Paraskevi, A.: An e-Learning management system for the Deaf people department of applied technologies. WSEAS Trans. Adv. Eng. Educ. **2**, 20–24 (2005)
19. Ng'ethe, G., Blake, E., Glaser, M.: SignSupport: a mobile aid for Deaf people learning computer literacy skills. In: Proceedings of the 7th International Conference on Computer Supported Education, vol. 2, pp. 501–511 (2015)
20. Calandro, E., Gillwald, A., Rademan, B.: SA broadband quality drops but prices remainhigh. In: Research ICT Africa (RIA) Policy Brief, pp. 1–5 (2014)
21. Blake, E., Tucker, W., Glaser, M., Freudenthal, A.: Case study 11.1: Deaf telephony: community-based co-design. In: Rogers, Y., Sharp, H., Preece, J. (eds.) Interaction Design: Beyond Human-Computer Interaction, 3rd edn, pp. 412–413. Wiley, Hoboken (2011)
22. Hutchins, E.: Distributed cognition. In: International Encyclopedia of the Social and Behavioral Sciences, pp. 1–10 (2000)
23. EqualSkills: What is Equalskills (2014)
24. Rogers, Y., Sharp, H., Preece, J.: Interaction Design: Beyond Human-Computer Interaction, 3rd edn. Wiley, Hoboken (2011)
25. W3C: Extensible Markup Language (XML) 1.0, 5th edn. (2014)
26. Oracle: Client Technologies: Java Platform, Standard Edition (Java SE) Release 8 (2014)
27. Hellstrom, G.: Draft application profile Sign language and lip-reading real time conversation application of low bitrate video communication (1998)
28. Sharpling, G.: Discourse Markers (2014)

Developing an E-Book-Based Learning Platform Toward Higher Education for All

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Abstract. While higher education rapidly grows worldwide, regional differences widen the digital divide. Our Creative Higher Education with Learning Objects (CHiLO), an e-book-based learning platform, aims to provide opportunities in higher education for developing countries or rural areas that have restricted digital literacy, digital devices, learning resources, and quality of networks. CHiLO provides an adaptable learning environment corresponding to diversification and flexibility in online courses such as massive open online courses (MOOCs) using device-agnostic m-learning centered on e-books with media-rich content. CHiLO also aims at a comprehensive open network learning system through the use of various existing technologies and various learning resources, including OER on open network communities such as SNS. Our set of experimental outcomes demonstrates the efficacy of m-learning using CHiLO, particularly with an e-book, including media-rich content, nano lectures, and digital badges.

Keywords: EFA · ICT4D · Online course · E-Book · E-Learning

1 Introduction

With opportunities for diversified employment rapidly expanding globally, including in developing countries or rural areas in addition to advanced countries, many people hope for opportunities to obtain higher education in various forms. From 1991 to 2013, the gross enrollment ratio (GER) increased from 8.6 % to 22.8 % in South and West Asia, from 4.0 % to 8.2 % in Sub-Saharan Africa, and with the widening of regional gaps to 76.6 % in North America and Western Europe [1, 2].

Any conventional educational system that includes building a school, hiring a teacher, and equipping a classroom eventually will be unable to cope with rapidly

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increasing demands for education [3]. In other words, a new education system, online education using information and communication technologies (ICTs) has many potentialities for higher education. Koller [4] described massive open online courses (MOOCs) that offer higher education opportunities, particularly for underprivileged communities, and alleviate the challenge of learning resource deficits, human and material, for rural areas.

However, in rural areas, there are low literacy rates and lack of technology-usage skills, high costs of accessing and owning ICTs, and acute shortages of electricity [6]; therefore, considerable cultural and physical differences exist between ICTs implementation and use in rural areas [5], and such differences prevent opportunities for higher education.

In rural areas, higher education opportunities for all require flexible and diversified learning environments that can resist unstable network infrastructure and unreliable power. We focused on recent trends of mobile devices' (smart phones and tablet PCs) rapid growth worldwide even in rural areas [7] to develop a new learning platform called Creative Higher Education with Learning Objects (CHiLO) that uses e-books compatible with many mobile devices not necessarily always connected to a network environment.

In this study, we report possibilities for CHiLO as a flexible and diversified learning platform through our experiment. The results provide evidence of the effectiveness of mobile devices with e-books.

2 Design Requirements for a Learning Platform

Information and communications technologies for development (ICT4D) aim to bridge ICTs and the digital divide (a gap due to socioeconomic underdevelopment) by ensuring equitable access to up-to-date communications technologies. An overview of the technology and processes of ICT4D consists of the following six components: infrastructure, hardware, software, interface, data, communication and processing (Fig. 1) [8]. These six components will also be useful for online learning platforms in rural areas.

2.1 Infrastructure and Hardware

Globally, approximately 60 % of people do not have Internet access [7]. Furthermore, 80 % of the world's people do not have a personal computer (PC) [9].

At the same time, mobile communication devices are so ubiquitously used in the world that "globally, mobile-broadband penetration will reach 32 % by the end of 2014—almost double the penetration rate just three years earlier (2011) and four times as high as that five years earlier (2009)" [7]. Mobile communication devices that provide satellite communication and a personal area network (PAN) such as bluetooth, a traditional telephone infrastructure, as well as Internet access are proliferating worldwide. In addition, these mobile communication devices do not depend only on the Internet. As Ally [10] stated, "It is true that many do not have desktop or laptop computers to access learning materials, but they have mobile devices and are now obtaining tablets with

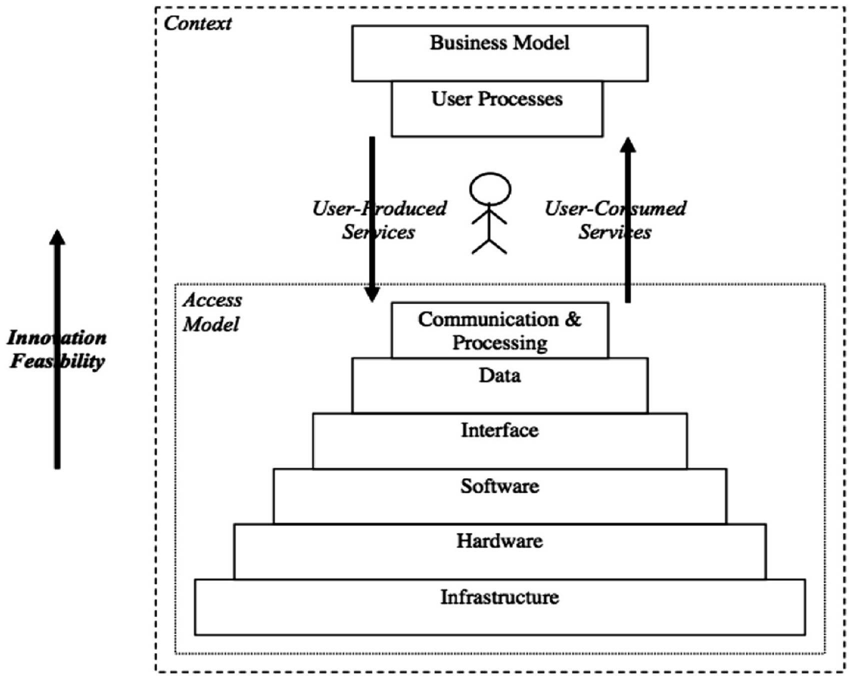

Fig. 1. Overview of the technology and processes of ICT4D [8].

wireless capability to allow them to access learning materials from anywhere and at any time."

Indeed, a project titled "Mobile Online Learning for Human Rights" was conducted in cooperation with the Kenya Human Rights Commission (KHRC). The primary goal was to create a platform to spread information freely about human rights to any Kenyan in order to increase knowledge and engagement. The research goals of this project were to explore the viability of using MOOC with incentives to reach, engage, and educate Kenyans. The course was free and open to anyone in Kenya; it offered both a digital badge and a certificate from Stockholm University in Sweden upon completion. Jobe and Hansson [11] asserted that "The current findings indicate that the availability of digital badges and certificates increased interest for participation and positively affected learning outcomes. Furthermore, the platform proved adequate for disseminating education in a developing country and allowed for unencumbered, ubiquitous access regardless of device."

A mobile ad-hoc network (MANET) is a network of mobile devices that are interconnected ad-hoc to share data. Data are shared in a multi-hop manner by being passed between devices, with each device having the potential to route data to another device in a mesh network. MANET is an effective approach to closing the digital divide in areas that do not possess reliable network connections such as the Internet [12].

The Digital Ubiquitous Mobile Broadband OLSR (DUMBO) project, initiated by the Asian Institute of Technology Internet Education and Research Laboratory, developed and tested a system for response to emergency scenarios in Thailand.

Adapting the concept of wireless mesh networks, DUMBO uses lightweight portable mobile nodes to broaden coverage and penetrate deep into areas not accessible by roads or where the telecommunication infrastructure has been destroyed [13]. Where the traditional wired infrastructure has been avoided because of prohibitive costs and unsympathetic geography, wireless technologies are attractive to governments, NGOs, and operators because they can be deployed in an inexpensive, decentralized, and effective manner in comparison with other solutions [12].

2.2 Interface

While the digital literacy of people in developing countries improves with each passing year [8], barriers such as low population density and remoteness, low levels of functional literacy, low disposable income, and constant struggle for survival still remain [14]. Although mobile devices are suited to online education in developing countries or rural areas [3, 8], devices with small screens, restrictive input methods, and limited battery life [15] leave some digital functions to be desired. For use in rural areas, a mobile device needs the special consideration of an excellent user interface.

2.3 Learning Resources

Online education in rural areas faces an acute shortage of learning resources such as content and materials, both in quality and quantity [3, 16–18]. Utilizing open educational resources (OERs) and MOOCs is the dominant approach to compensate for insufficiency, although there are problems in that part of MOOCs, which restrict translating and reprocessing work because of licensing, do not meet the need.

Another approach to reduce the shortage of learning resources is micro learning, for instance, competency-based education (CBE). CBE is designed to fit each learner: combined small and complete competency units are adapted to learners' competencies. Therefore, learning resources are available any time, and each competency unit is reusable [19]. The introduction of CBE enables the utilization of limited learning resources more effectively.

2.4 Communication and Processing

Many studies strongly suggest that cooperative learning is more effective than individual learning in contributing to motivation, raising achievement, and producing positive social outcomes [20]. Interactive learning using social networking services (SNS) such as Twitter, Facebook, and LinkedIn has dramatically developed cooperative learning [21, 22].

In rural areas, mobile devices have rapidly gained popularity. Mobile devices improve communication among social network members nationally and internationally, and they are increasingly changing the nature of knowledge in modern societies [8, 10, 18].

In addition, online classrooms using SNS through mobile devices solve the challenge of resource deficits, for example, teachers and educational materials; this can also be very effective in the brick-and-mortar classrooms of rural or impoverished areas [3].

3 E-Book and EDUPUB

An e-book has the advantage of being easily carried in some device—a mobile phone or tablet PC—without a network. Using e-books provides a new way of learning adapted to the network-learning model.

The e-book, which is not only device independent but also available off- or online, has adopted m-learning. Furthermore, e-books have the interoperability of EPUB and major e-book formats, namely Kindle's K8 format, iBook's .iBooks format, and others [23]. EPUB3 is a distribution and interchange format standard for e-books, developed by the International Digital Publishing Forum (IDPF) [24].

With the advent of the EPUB3 format, e-books now include media-rich and interactive contents. IDPF 2015 defines this capability as follows: "The EPUB specification is a distribution and interchange format standard for digital publications and documents. EPUB defines a means of representing, packaging, and encoding structured and semantically enhanced Web content—including HTML5, CSS, SVG, images, and other resources—for distribution in a single-file format." Thus, the EPUB3 format has greater sourcing flexibility. In the education field, learning materials in the EPUB3 format are easily repurposed by tutors, adapted to improve learning outcomes, and offer a way of avoiding vendor lock-in [26].

IDPF has proposed the EDUPUB format to meet requirements of next-generation learning content on the basis of the e-book EPUB3 format [25]. EDUPUB implemented a system for cooperation with the Learning Management System (LMS), the Analytics System, the Student Information System (SIS), and the assessment system on EPUB3 using JavaScript and JavaScript Object Notation (JSON) (Fig. 2).

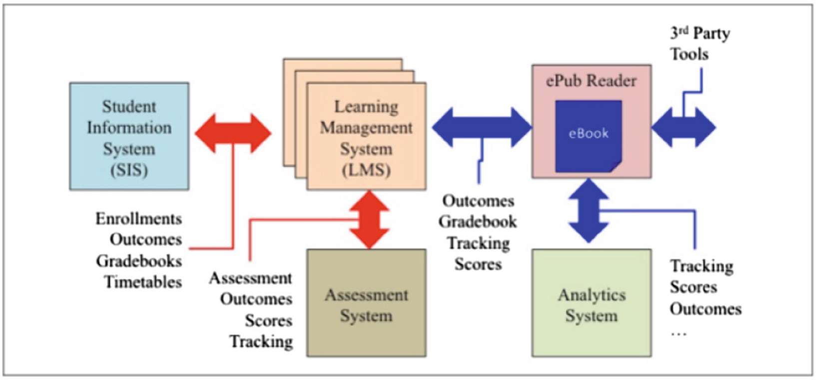

Fig. 2. Overarching EDUPUB architectural model [25].

Smith and Kukulska-Hulme [27] reported the following on results of an 18-month project (2010–12) led by the Institute of Educational Technology (IET) at the Open University, United Kingdom:

1. E-books on portable devices are appropriate for the lifestyle needs of distance-education students.
2. When available, Internet access only enables timely downloading and use. “Situational reading” occurs when one or more books with the desired content are accessible to learners when needed, thus matching readers’ requirements in relation to their current situation.
3. An e-book can contain in one package all the resources needed by a student.

E-books are now being introduced into education, and their improvement has been widely studied. EDUPUB is one of the elegant solutions. However, the implementation of these applications is still being discussed. Furthermore, EUPUB is not necessarily focused on use in rural areas.

4 CHiLO Framework

E-books suit an application of IT-driven education systems in rural areas with poor networks. For implementing a flexible learning environment in rural areas, our CHiLO incorporates the EPUB3 format for e-books and consists of four components as follows (Fig. 3):

- CHiLO Book using e-books in the EPUB3 format
- CHiLO Lecture based on one-minute nano lecture

Fig. 3. Implementation of four CHiLOs.

- CHiLO Badge providing authentication and certification
- CHiLO Community such as SNS, bulletin boards, and chat rooms

4.1 CHiLO Book

The core component of CHiLO, created through an e-book with an EPUB3 format, contains media-rich contents, including graphics, animation, audio, and embedded video. The CHiLO Book based on CBE consists of learning materials for a classroom hour. Those who complete a CHiLO Book receive a CHiLO Badge as a certificate of completion.

Another idea for online education involves the use of e-books by EDUPUB. However, most e-book readers do not currently support the media-rich functions of the EDUPUB format, such as embedded videos, JavaScript compliance, and JSON. One reader that does support JSON is Readium, which is an open-source EPUB reader developed by IDPF. One of Readium's disadvantages is that it currently does not support mobile devices such as smartphones and tablets. The CHiLO Book offers a realistic solution by combining an e-book reader and a Web browser. The EPUB3-based CHiLO Book ensures access to a learning environment anytime, anywhere, even without Internet connection, thereby avoiding the difficulties of most e-books. The CHiLO Book as an e-book is also available in e-book stores, for instance, the iTunes Store and Google Play Books. Another potential disadvantage of an e-book is that it requires a special application such as an e-book reader and must be downloaded into the e-book reader. Learners without this access will need to use the Web-based CHiLO Book.

4.2 CHiLO Lecture

CHiLO Lecture comprises a video with scripts, some quizzes, and other learning materials. The video is a one-minute nano lecture. This concept originated from an experiment showing that the viewing time of most online learners is approximately one minute [28].

A CHiLO Lecture is equivalent to one page in a traditional textbook. A CHiLO Book includes approximately 10 CHiLO Lectures and a link to a comment box allowing the user to post to Facebook. Furthermore, each page of the book has a link to quizzes on the material presented. A standard CHiLO course, comparable with a traditional university course with one academic credit, comprises 10 CHiLO Books.

4.3 CHiLO Badge

In online courses, performing indirect assessments such as those on learning time and academic workload is difficult. Although CHiLO adopted a direct assessment approach for learning outcomes, the completion of a CHiLO course is measured in standard course hours corresponding to academic credits.

Whenever learners complete a CHiLO Book, they receive a CHiLO Badge, which is a simple mechanism of outcome assessment in CHiLO. When tutors wish to check a learner's progress, they simply ask the learner to present the CHiLO Badge. They do not need to confirm with indirect assessment tools such as gradebooks, tracking past results, and test scores. Badges increase motivation, and different types of badges can affect learning performance [29].

4.4 CHiLO Community

A learning community called CHiLO Community combines an open SNS on the Web such as Facebook and Twitter, with a forum of LMS. Learners ask questions, have discussions, and exchange information about their CHiLO Books.

In a CHiLO Community, a tutor is incapable of teaching many learners. A CHiLO Community consists of many learners and a few tutors called "connoisseurs," who act as substitutes for teachers. A learner who studies and completes CHiLO Book in a specific field can become a connoisseur. The connoisseur and learner stand on equal ground so that a connoisseur frequently exchanges information with learners in their communities.

In a CHiLO Community, learners do not learn from a tutor but on their own, with CHiLO Book as the learning materials. Thus, learners are constantly required to find suitable CHiLO Books in the community.

5 Applying the CHiLO Framework for MOOC

5.1 Methodology

We produced a series of CHiLO Books called "Nihongo Starter A1 (NSA1)" in cooperation with the Open University of Japan (OUJ) and the Japan Foundation. We delivered them as a learning course of OUJ-MOOC in JMOOC: JMOOC "is an organization that was formed in 2013 with the cooperation of Japanese universities and businesses that aims to spread and magnify Japanese MOOCs throughout the country" (http://www.jmooc.jp/en/about/).

NSA1 comprises 10 e-books for learners who want to study Japanese. A single package of an e-book is equivalent to one lesson.

The NSA1 series' functions of assignment tests and issuing badges were implemented by linking Moodle modules of quizzes and badges. Both the formats included hyperlinks to Facebook groups, which were created as the "CHiLO community" and were opened for learners and teachers.

As a demonstration experiment, we distributed CHiLO Books of the NSA1 series in approximately one year (from April 2014 to March 2015), at no charge, through the three different distribution channels shown in Table 1. Among these distribution channels, the OUJ-MOOC site is one of the platforms supported by JMOOC, which is an MOOC provider in Japan (http://www.jmooc.jp/en/about/).

Table 2 shows the start and end dates and terms in which each class (Class 1–Class 5) was held as a CHiLO community. In each community/class and term, our staff members

Table 1. Distribution channels.

Distribution channels	EPUB3-based	Web-based
OUJ-MOOC site	√	√
iBooks Store (Apple Store)	√	N/A
Google Play Books	√	N/A

Table 2. Learning communities as CHiLO communities.

	Start	End	Term
Class 1	4/14/2014	5/1/2014	35 days
Class 2	6/2/2014	7/6/2014	35 days
Class 3	8/4/2014	10/15/2014	73 days
Class 4	11/3/2014	12/21/2014	49 days
Class 5	1/12/2015	3/22/2015	70 days

in the support team for NSA1 facilitated discussions and question-and-answer sessions among the community.

5.2 Results

A. Number of downloads of CHiLO Books

Table 3 shows the number of downloaded NSA1 CHiLO Books by country and region. Although there were legal restrictions in some countries and regions on downloading EPUB3-based CHiLO Books in the iBooks Store and Google Play Books, in this demonstration experiment, we found that CHiLO Books had been downloaded in 109

Table 3. Number of downloads of NSA1 CHiLO Books.

Countries and regions	Total	Google play	IBooks Store	OUJ-MOOC
United States	3,625	1,214	1,844	567
Indonesia	2,022	1,578	0	444
Japan	1,833	488	701	644
Thailand	1,384	1,308	0	76
Philippines	1,201	826	0	375
Mexico	710	88	164	458
Malaysia	690	541	0	149
Colombia	678	14	31	633
Venezuela	532	16	11	505
Brazil	499	183	69	247
Others (99)	8,954	2,114	895	5,945
Total (109)	22,128	8,370	3,715	10,043

countries and regions: Google Play Books in 45 countries, iBooks Store in 34 countries, and OUJ-MOOC in 109 countries and regions. Particularly, CHiLO Books were frequently downloaded in rural areas: Indonesia (2,022), Thailand (1,833), Philippines (1,201), Mexico (710), Malaysia (690), Colombia (678), Venezuela (532), and Brazil (499). This results show that the CHiLO Book and these format appeals to people in rural areas.

B. Device use

Questionnaire results from those who earned badges in this demonstration experiment (n = 105) are as follows (Table 4):

Table 4. Questionnaire results: Which CHiLO Book did you use: EPUB3-based or Web-based CHiLO Book? (n = 105).

Mostly used the eBook version	17	50.5 %
Mainly the eBook version, sometimes the Web version	13	
Used both the eBook version and the Web version at the same rate	6	
Mainly the Web version, sometimes the eBook version	17	
Mostly used the Web version	52	49.5 %

- In total, 91.4 % (96) of the respondents learned with the CHiLO Books at home.
- In total, 79.0 % (83) of the respondents primarily used PCs.
- In total, 50.5 % (53) of the respondents used the EPUB3-based CHiLO Books in some way.

With regard to the analysis of device-specific access to the Moodle quiz module, 56.1 % (1,771) accessed from PCs, 18.1 % (572) from tablet PCs, and 25.8 % (831) from smartphones (Fig. 4).

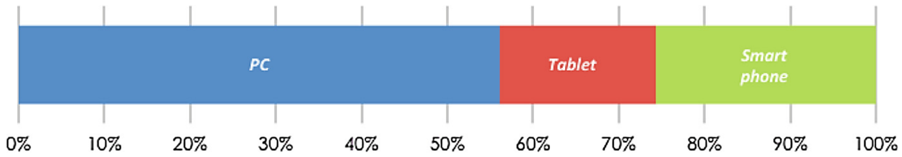

Fig. 4. Ratio of traffic of quizzes in each CHiLO Book by device.

Furthermore, we divided access logs into EPUB3-based and Web-based CHiLO Books; in the case of Web-based books, approximately 69 % of accesses were from PCs; in the case of EPUB3-based books, approximately 73 % accessed from mobile devices such as smartphones and tablet PCs (Fig. 5).

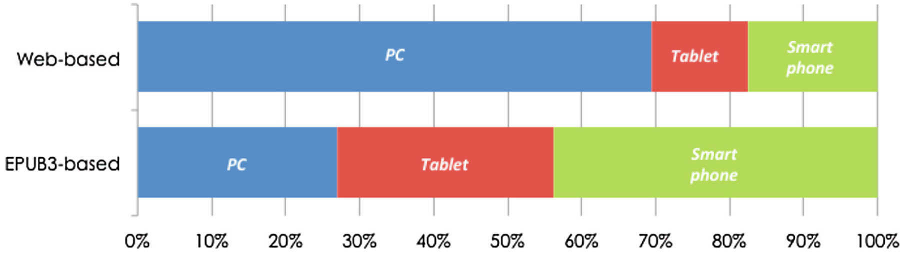

Fig. 5. Ratio of people who responded to the questionnaire by the CHiLO Book format and devices.

C.
Learning Community

Learners can access the distribution channels shown in Table 1 at any time and from any location. In the CHiLO community, to increase the desire to learn, we continued to post messages to notify participants of the assigned CHiLO Book and showed a standardized learning schedule each week.

Table 5 shows that participants of each class (Class 1–Class 5) acquired all 10 badges of the 10-volume CHiLO Books.

Table 5. Participated in Facebook group and earned all 10 badges.

	Participated in Facebook group	Issued all 10 badges
Class 1	448	2
Class 2	852	7
Class 3	1491	105
Class 4	287	26
Class 5	103	14

Figure 6 shows the number of badges issued daily over 1 year.

The number of badges issued tended to be high in terms of each class (Class 1–Class 5).

Table 6. Standardized schedule for class 3.

Term	Learning Objective
1st week	Lessons 1 and 2
2nd week	Lessons 3 and 4
3rd week	Lessons 5 and 6
4th week	Lessons 7 and 8
5th week	Lessons 9 and 10
6th–10th week	Supplementary classes

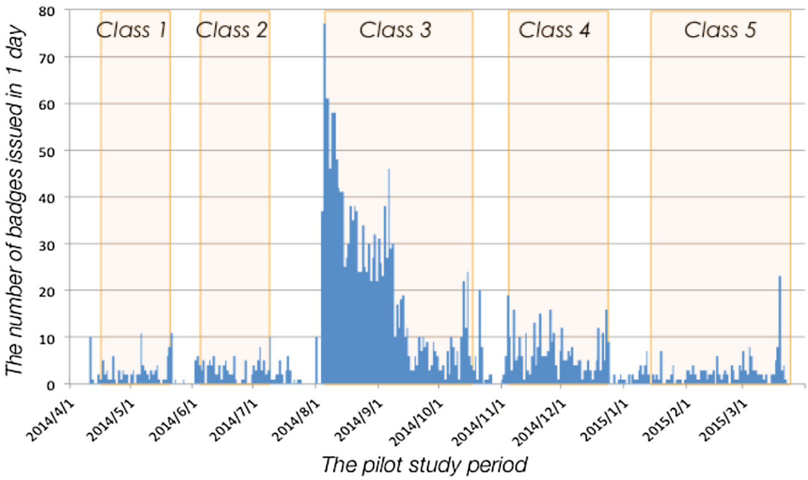

Fig. 6. Daily number of badges issued over 1 year.

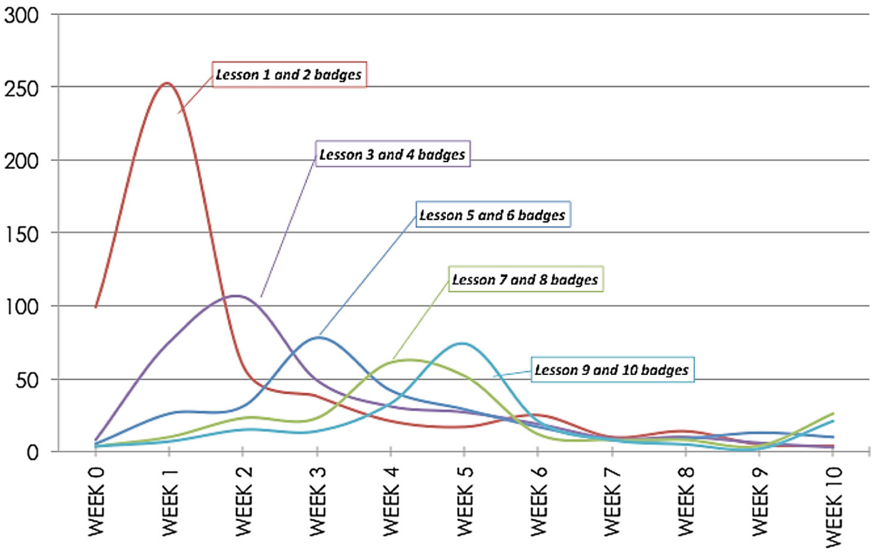

Fig. 7. Time period for earning badges on each lesson.

Table 6 shows the standardized schedule of Class 3. Figure 7 shows the badge acquisition status during the schedule of Table 6. Learners attempted to acquire badges before beginning the supplementary classes, prompted by our notification.

Figure 8 shows 1,491 participants who joined Class 3. Of 1,491 participants, 336 learners, or over 20 %, posted messages. Moreover, 329 learners posted certain comments responding to these messages, and 709 learners, or 40 % of the participants in the Facebook group, sent Likes. Considering that only 1 % of users post messages

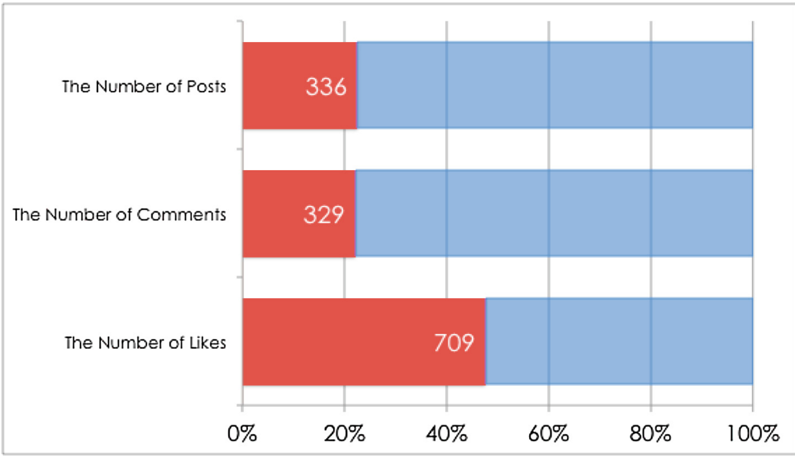

Fig. 8. Activities of those who joined the facebook group.

and only 9 % post comments in general online communities [30], learners in this community were relatively active.

6 Discussion

6.1 Evaluation

From results of the demonstration experiment, we believe that the CHiLO system has three advantages.

First, CHiLO can offer flexible formats, wherein we can provide learning content to people in different countries. Although CHiLO Books were unfamiliar to most people who participated in the experiment, we successfully delivered our books to a large number of people, including those in rural areas.

Second, while we did not appeal to learners to choose either the Web-based or the EPUB3-based CHiLO Book in this demonstration experiment, some learners responded to our questionnaire as follows: "I used both types depending on where I was and how long I had. I used the EPUB3 type to review the contents when I was in the office or elsewhere and the Web type when I was at home and could work more peacefully."

Presumably, learners in this demonstration experiment tended to switch devices effectively depending on their Internet connection; they would learn through Web-based CHiLO Books on PCs when they had access to the Internet at home or at school. In contrast, they would download EPUB3-based CHiLO Books and learn the contents on their own mobile devices such as smartphones or tablet PCs when they did not have Internet access. CHiLO can potentially provide a device-independent and ubiquitous learning environment in which learners select Web-based or EPUB3-based CHiLO Books according to their preferences.

Finally, a type of mutual learning occurred in the learning community. While the badge-earning rate in this experiment was not very high, many participants posted in the learning community that they were happy with the community and showed off the badges they had achieved. Participants who had completed the series tended to provide helpful suggestions to participants following them. In addition, Spanish-speaking learners volunteered to form a learning group in which they translated the CHiLO Books into Spanish. Learners who had completed the course tended to provide helpful suggestions to learners following them.

6.2 Issues

An issue in the demonstration experiment is that learners did not completely enjoy the merits of EPUB3-based CHiLO Books.

Some learners reported as follows:

1. Videos embedded in EPUB3-based CHiLO could not be played.
2. Assessment examinations embedded in EPUB3-based CHiLO could not be connected.
3. EPUB3-based CHiLO Books were not successfully downloaded.

In the first case, despite the embedded videos meeting specifications of EPUB3, many existing e-book readers on EPUB3 do not support embedded videos. In a later investigation, an e-book reader, which had not been recommended, did not work as expected with embedded videos.

In the second case, a learner can read the CHiLO Book without a network connection but can take assessment examinations only with a network connection. Consequently, the learning environment becomes somewhat complex.

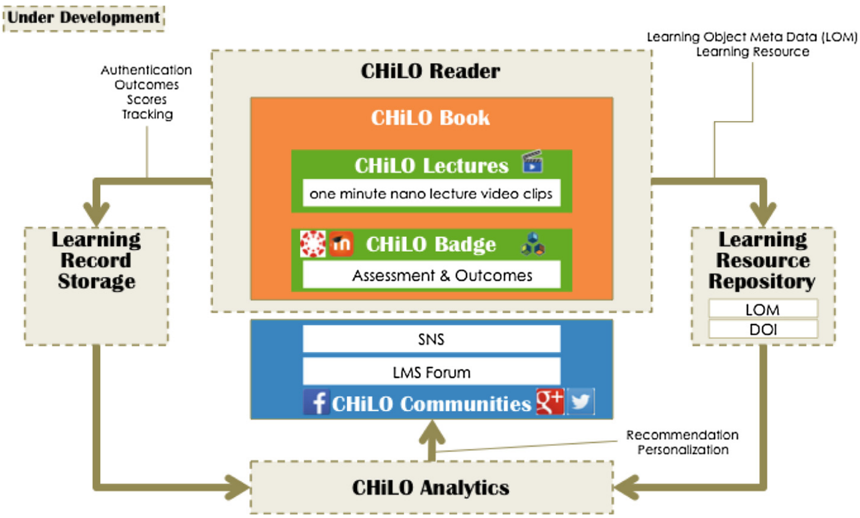

Fig. 9. CHiLO Book architecture.

In the third case, the file size of a CHiLO Book is 20 Mbytes at the maximum, and that is not a large size in a constant-connection network. Even so, this size imposed strict limits in some regions.

7 Conclusions and Future Work

With regard to geographical digital divide issues, CHiLO offered affordable formats for people in 109 countries and regions, including developing countries and/or rural areas. In addition, the learners selected Web-based or EPUB3-based CHiLO Books on PCs or smartphones according to their preferences and lifestyles. These results demonstrate that CHiLO can provide flexible, diverse learning environments that are also device independent, network independent, and anytime and anywhere.

These results reveal that CHiLO has plenty of potential for mobile learning in limited network environments; thus, CHiLO resolves these physical problems in rural areas. At the same time, CHiLO including CHiLO Book, which provides a user interface similar to that of an e-book wherein readers can literally flip a page without any difficulty, resolves cultural problems, such as the challenge of digital illiteracy.

However, CHiLO has some challenges such as the issue of some existing e-book readers. To reduce those problems, we will soon release a dedicated e-book reader for CHiLO Book to enhance the usability of CHiLO Book called CHiLO Reader. The CHiLO Reader is compliant with EPUB3, with embedded video, JavaScript, and JSON data. This enables the development of all embedded-type CHiLO Book that contains assessment examinations and a digital badge-issuing feature. It is possible to enjoy learning activities without an Internet connection, such as viewing a video lecture and resulting in earning a badge. The CHiLO Reader also has the feature of recording learning history (outcomes, scores, tracking, and others) in defect of connecting networks. Once it is connected to the Internet, those records send the history to the Learning Record Storage (Fig. 9).

To use CHiLO in a restricted network environment is another challenge. We attempted to implement MANET in the CHiLO Reader. Thus, each learner of the CHiLO Reader can build an ad-hoc network, with each device having the potential to route data to another device in a mesh network.

References

1. Varghese, N.V.: Globalization, economic crisis and national strategies for higher education development. In: International Institute for Educational Planning (IIEP) Research Paper, UNESCO. Paris: IIEP (2009)
2. UNESCO EFA: Education for all 2000–2015: achievements and challenges (2015)
3. Usha, R.V.R.: Primer 1: An introduction to ICT for development. Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT). Chapter 3. ICTD Applications in Core Sectors of Development, pp. 81–109 (2011)
4. Koller, D.: What we're learning from online education (2012). http://www.ted.com/talks/daphne_koller_what_we_re_learning_from_online_education. Accessed 17 August 2015

5. Heeks, R.: Information systems and developing countries: failure, success, and local improvisations. Inf. Soc. **18**(2), 101–112 (2002)
6. Asiimwe, E.N., Wakabi, W., Grönlund, Å.: Using technology for enhancing transparency and accountability in low resource communities: experiences from Uganda. In: ICT for Anti-Corruption, Democracy and Education in East Africa, vol. 37, pp. 37−51 (2013)
7. ITU: The World in 2014: ICT facts and figures (2014). https://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2014-e.pdf. Accessed 17 August 2015
8. Heeks, R.: The ICT4D 2.0 Manifesto: where next for ICTs and international development?, Manchester Centre for Development Informatics, Development Informatics Working Paper Series (2009)
9. The World Bank: Mobile phone access reaches three quarters of planet's population (2012). http://www.worldbank.org/en/news/press-release/2012/07/17/mobile-phone-access-reaches-three-quarters-planets-population. Accessed 17 August 2015
10. Ally, M., Samaka, M.: Open education resources and mobile technology to narrow the learning divide. Int. Rev. Res. Open Distrib. Learn. **14**(2), 14–27 (2013)
11. Jobe, W., Hansson, P.: Mobile learning for human rights in Kenya: the Haki Zangu case for non-formal learning. In: ICT for Anti-Corruption, Democracy and Education in East Africa, p. 67 (2013)
12. Stan, K.: New & emergent ICTs and climate change in developing countries. Center for Development Informatics. Institute for Development Policy and Managment, SED. University of Manchester (2011)
13. Kanchanasut, K., Tunpan, A., Awal, M.A., et al.: DUMBONET: a multimedia communication system for collaborative emergency response operations in disaster-affected areas. Int. J. Emerg. Manag. **4**(4), 670–681 (2007)
14. Bhavnani, A., Chiu, R.W.W., Janakiram, S., et al.: The Role of Mobile Phones in Sustainable Rural Poverty Reduction. World Bank Global Information and Communications Department, Washington (2008)
15. Parsons, D., Ryu, H., Cranshaw, M.: A design requirements framework for mobile learning environments. J. Comput. **2**(4), 1–8 (2007)
16. Marais, M.: Analysis of the factors affecting the sustainability of ICT4D initiatives (2011)
17. Colle, R.: Building ICT4D capacity in and by African universities. Int. J. Edu. Develop. Using ICT **1**(1), 101–107 (2005)
18. Smith, M.L.: Being Open in ICT4D. SSRN (2014)
19. Johnstone, S.M., Soares, L.: Principles for developing competency-based education programs. Change: Mag. High. Learn. **46**(2), 12–19 (2014)
20. Chen, B., Bryer, T.: Investigating instructional strategies for using social media in formal and informal learning. Int. Rev. Res. Open Distrib. Learn. **13**, 87–104 (2012)
21. Siemens, G.: Connectivism: Learning as network-creation (2005). http://www.elearnspace.org/Articles/networks.htm
22. Downes, S.: An introduction to connective knowledge (2005). http://www.downes.ca/post/33034. Accessed 17 August 2015
23. Bläsi, C., Franz, R.: On the interoperability of eBook formats. Report for European Booksellers Federation and International Booksellers Federation presented to the EU Commissioner for the Digital Agenda (2013)
24. Polanka, S.: What Librarians Need to Know About EPUB3 (2013). http://corescholar.libraries.wright.edu/ul_pub/159/. Accessed 17 August 2015
25. IDPF: EPUB 3 EDUPUB Profile Draft Specification (2015). http://www.idpf.org/epub/profiles/edu/spec/. Accessed 17 August 2015
26. Belfanti, P.: What is EDUPUB (2014). http://www.imsglobal.org/edupub/WhatisEdupubBelfantiGylling.pdf. Accessed 1 August 2014

27. Smith, M., Kukulska-Hulme, A.: Building m-learning capacity in higher education: E-books and iPads. In: Specht, M., Multisilta, J., Sharples, M., (eds.) World Conference on Mobile and Contextual Learning Proceedings. Helsinki: CELSTEC & CICERO Learning, pp. 298–301 (2012)
28. Hori, M., Ono, S., Kobayashi, S., Yamaji, K. et al.: Peer-to-peer Learning on Large Scale Online Courses: Focusing on Lurkers. In: 6th International Conference on e-Learning and Innovative Pedagogies (2013)
29. Abramovich, S., Schunn, C., Higashi, R.M.: Are badges useful in education?: it depends upon the type of badge and expertise of learner. Edu. Tech. Res. Dev. **61**(2), 217–232 (2013)
30. Nielsen, J.: The 90-9-1 Rule for Participation Inequality in Social Media and Online Communities (2006). http://www.nngroup.com/articles/participation-inequality/Pitigala. Accessed 17 August 2015

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