Lecture Notes in Educational Technology

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Innovations in Smart Learning

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Preface

Smart learning environments are emerging as an offshoot of various technology-enhanced learning initiatives that have aimed over the years at improving learning experiences by enabling learners to access digital resources and interact with learning systems at the place and time of their choice, while still ensuring that appropriate learning guidance is available to them there and then.

The concept of what constitutes smart learning is still in its infancy, and the International Conference on Smart Learning Environments (ICSLE) has emerged as the platform to discuss those issues comprehensively. It is organized by the International Association on Smart Learning Environments and aims to provide an archival forum for researchers, academics, practitioners, and industry professionals interested and/or engaged in the reform of the ways of teaching and learning through advancing current learning environments towards smart learning environments. It will facilitate opportunities for discussions and constructive dialogue among various stakeholders on the limitations of existing learning environments, need for reform, innovative uses of emerging pedagogical approaches and technologies, and sharing and promotion of best practices, leading to the evolution, design and implementation of smart learning environments.

The focus of the contributions in this book is on the interplay of pedagogy, technology and their fusion towards the advancement of smart learning environments. Various components of this interplay include but are not limited to:

- Pedagogy: learning paradigms, assessment paradigms, social factors, policy
- Technology: emerging technologies, innovative uses of mature technologies, adoption, usability, standards, and emerging/new technological paradigms (open educational resources, cloud computing, etc.)
- Fusion of pedagogy and technology: transformation of curriculum, transformation of teaching behavior, transformation of administration, best practices of infusion, piloting of new ideas.

ICSLE 2016 received 52 papers, with authors from 18 countries. All submissions were peer-reviewed in a double-blind review process by at least 3 Program Committee members. We are pleased to note that the quality of the submissions this year turned out to be very high. A total of 13 papers were accepted as full papers (yielding a 25 % acceptance rate). In addition, 8 papers were selected for presentation as short papers and another 7 as posters.

Furthermore, ICSLE 2016 features 2 distinguished keynote presentations. One workshop is also organized in conjunction with the main conference, with a total of 4 accepted papers (included at the end of this volume).

We acknowledge the invaluable assistance of the Program Committee members, who provided timely and helpful reviews. We would also like to thank the entire Organizing Committee for their efforts and time spent to ensure the success of the conference. And last but not least, we would like to thank all the authors for their contribution in maintaining a high quality conference.

With all the effort that has gone into the process, by authors and reviewers, we are confident that this year's ICSLE proceedings will immediately earn a place as an indispensable overview of the state of the art and will have significant archival value in the longer term.

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Contents

Examining the Relationships between Foreign Language Anxiety and Attention during Conversation Tasks

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Abstract. This study explored the association between Foreign Language Anxiety and sustained attention during two conversation tasks. Participants were twenty-nine EFL (English as a Foreign Language) learners who completed a role play task in a classroom practice condition and a real-world situated condition. Attention levels were measured using Neurosky's EEG headset during the task. Self-perceived language anxiety was measured using questionnaire after the task. Correlation analyzes show there was a negative correlation between attention levels and states of language anxiety in the classroom practice condition but there was a positive correlation between attention levels and states of language anxiety in the real-world situated condition. Findings suggest that students who experience low anxiety tend to sustain better attention during the language task; however, their attention can be enhanced when they feel more anxiety resulting from a more challenging task. Implications for language instructors and system developers are discussed.

Keywords. Neurosky EEG headset ·Communicative task ·Attention ·Foriegn language anxiety ·Technology-enhanced language learning

1 Introduction

Communicative language teaching (CLT) has been widely used in classroom to promote communicative competence in English. In a CLT classroom, task-based learning activities are used to promote meaningful interaction, introduce authentic context and solve a problem. However, learners' performance can be affected by the interaction between the complexity of a learning task and individual differences. Learners' affective variables, such as language anxiety, can affect language comprehension and production [1].

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State of language anxiety refers to an anxiety that EFL learners experience during a language task [1]. Research indicates that low anxiety state has a positive impact on perceived communicative competence and willingness to communicate [2], which is associated with the amount of language output. Studies have found that lower measures of language anxiety can lead to more oral production and more modified utterances (see [5] for a review). On the other hand, high language anxiety tends to be negatively correlated with L2 achievement [3]. Some explanation has been proposed in terms of cognitive interference. When one's anxiety arousal is high, the attention can be divided between task-related cognition and self-related cognition such as excessive self-evaluation and worry over potential failure, which makes cognitive performance less efficient [4].

While some studies suggest that anxiety disrupts cognitive processing, several researchers believe that a certain degree of anxiety can have a positive effect because anxiety might lead to greater effort put by the learners. Eysenck (1979) argued that anxiety can reduce effectiveness, but it will not necessarily impair performance efficiency if sufficient effort is exerted. Similarly, other studies found that there is no relationship between language anxiety reported in the diary and learners' rate of improvement. Based on the brief overview, the results are mixed and most research has concentrated on its impact on language output, or performance rather than processing during a task [5].

Thus, of interest to the research team is how attention states correlate with language anxiety during a language task. Generally, attention can have different forms, including focused attention, shifting attention and selective attention and divided attention [6]. The attention inspected in this paper is sustained attention, which is a component of attention that reflects learners' readiness to respond to stimuli over a period of time [7].

With the advancement of biosensor technology, it is possible to monitor learners' mental states during a task. Using the EEG headset developed by Neurosky, physiological signals in the brain, such as attention, an indicator of the degree of the intensity of mental "focus" or "attention" a person feels, can be detected. The physiological signals can be turned into readable values, called eSense, ranging from 1 to 100 on a relative scale using Neurosky's algorithms. On this scale, values between 40 to 60 at any given moment in time are considered "neutral." Values from 80 to 100 are considered "elevated," indicating strongly heightened levels of that eSense. Similarly, on the other end of the scale, values between 20 to 40 are considered "reduced," while values between 1 to 20 indicate "strongly lowered" levels [8]. Studies using Neurosky's EEG headsets have been able to use it to track attention states across different learning tasks [6, 9, 10, 14]. Rebolledo-Mendez et al. created an assessment exercise in Second Life to examine the correlation between the attention measured by eSense, or MindSet in their study, and self-reported attention levels measured by the Attention Deficit and Hyperactivity disorder test during the interaction in the assessment exercise [14]. A positive correlation was found, indicating that eSense provides accurate readings related to self-reported attention levels.

The present study attempted to examine how different levels of language anxiety induced by two language tasks would affect the attention states as measured by the EEG headset as well as examine the correlation between on-task attention states and language anxiety states during language tasks. Two types of common language tasks were designed: (1) classroom role play (2) real-world role play. The classroom task represents how language is normally practiced in the class while the real-world type of task simulates authentic situation where language is used. The former induces low level of language anxiety and the latter involves heightened level of language anxiety.

2 Research question

The two following research questions guide this study:

RQ1: How do attention states vary by langauge tasks involving different levels of foreign language anxiety?

RQ2: What is the correlation between attention and self-perceived langueage anxiety during a language task?

3 Research design

3.1 Participants

Twenty-nine undergraduate and graduate students participated in the experiment. Their ages ranged between 19 to 25 with 36.7% female and 63.3% male. They were native speakers of Chinese learning English as a foreign language, who learned English for nine years on average. The majority of participants are from the college of Management (76.7%), and some are from the college of Technology (20%) and the college of Liberal Arts (3.3%). Their average percentile of English scores on the college entrance exam (range 0 to 15) were 12.46 (SD = 1.84), which is equivalent to intermediate high proficiency level.

3.2 Instruments

There are two dependent variables in this study, self-perceived language anxiety and brainwave. To measure the self-perceived language anxiety, the Foreign Language Classroom Anxiety Scale was adopted from Reinders and Wattana [11]. The Foreign Language Classroom Anxiety Scale was translated to Chinese and tailored to meet our language context. The questionnaire consisted of five items, which were rated on a five point Likert scale, ranging from 1 being “strongly disagree” to 5 being “strongly agree.” The internal consistency coefficient was satisfactory for the classroom practice condition (cronbach’s α = .80) and for the real-world situated condition (cronbach’s α = .66). Another questionnaire, consisting of three items tapping into task complexity, time constraints and interlocutor pressure, was designed for the manipulation check. It was rated on a 5-point scale ranging from strongly disagree to strongly agree.

3.3 Language tasks

The goals of the language tasks are to induce low and heightened levels of language anxiety and design two conversation tasks that are meaningful and relevant to actual language use. Based on the consultation with university-level English instructor and factors related to speaking-in-class anxiety [12], two types of role-play tasks were designed to create two situations commonly encountered by language learners: (1) classroom type of role play (2) real-world type of role play. They differ in the following aspects (table 1).

Table 1. Types of role play tasks and their design principle

	Classroom situation	Real-world situation
Task difficulty	Simple ordering	Authentic ordering
Time limit	Sufficient time	Limited time
Interlocutor	Student partner	English speaking partner
Expected anxiety level	Low anxiety inducing	Heightened anxiety inducing

These factors are the ones that have been found to associate with different levels of language anxiety. The degree of task difficulty, time urgency, and talking to a student partner or English speaker in these tasks were also manipulated in a way that simulates communicative tasks.

The task begins with an ordering instruction with a setting in a coffee shop. The classroom task simulates the classroom practice situation that is less anxiety-inducing. In this situation, participants are asked to order specific coffee and manage to checkout. The content only prompts the use of fixed expressions to complete the tasks, i.e., I’d like to have a hot Venti latte. To go. Sufficient time is given with 3 minutes maximum. The conversation is practiced with a low-stake partner at similar age and with similar English proficiency. The real-world task simulates a more authentic conversation, which prompts the participants to engage in a rather open-ended ordering situation, i.e., I’d like to add an extra shot of expresso. Top it with extra whipped cream. The task also limits the task time to two minutes but actually gives three minutes. The conversation was carried out with a Malaysia-born English speaker as a conversation partner. This task is relatively high anxiety-inducing.

3.4 System description

Tablets and Neurosky EEG headsets were the devises used in this experiment. A web-based system was developed for facilitating the language tasks where participants can use the tablet to connect to our web page. The Neurosky’s EEG headsets were used to collect participants’ brainwave throughout the language tasks. We use C# and Neurosky's EEG headset SDK to develop the program, connect the Neurosky’s EEG headset through Bluetooth, and design a website with task content and countdown function by using HTML and JavaScript language.

3.5 Procedures

Since this is a within-subject design, we randomly assigned participants into two groups, A and B, to fulfill a counterbalance design (see figure 1).

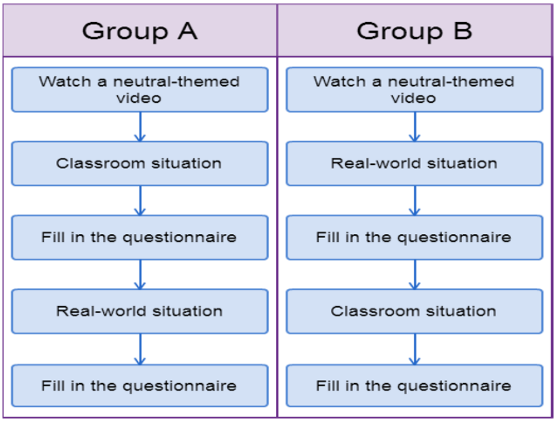

Fig. 1. Experimental procedure

Before participants began the language tasks, they were led to wear Neurosky's EEG headset. To neutralize participants' emotion, they were asked to watch a three-minute neutral-themed video. Then participants began the role play tasks with the designated partners while following task instruction on the tablet and referring to a print menu to complete the task (see figure 2). Depending on the group the participants were assigned to, they either went through the classroom practice task first and then the real-world simulated task or vice versa.

Fig. 2. A menu and a table for the conversation tasks

Fig. 3. Subject participating in the real-world situated condition

Participants in the classroom practice condition were assigned to converse with a college student and were told that they would use as much time as needed to complete the task. Those in the real-world situated condition were assigned to talk with a nearly native-like English speaker and were told that they were only given two minutes to complete the task while they were actually given sufficient time to finish the task (see figure 3). After they complete each of the tasks, they were required to fill in the Foreign Language Classroom Anxiety Scale. They were also given manipulation check questions regarding the anxiety inducing factors. Finally, they were debriefed and thanked for their participation with a gift card.

4 Results and discussion

4.1 Analysis of manipulated factors

To test if the three anxiety inducing factors were successfully manipulated during the tasks, three paired-t tests were conducted (table 2). The results showed that the three factors in the real-world situation all led to higher self-perceived task difficulty, $t(28) = -5.13$, $p < .001$, time constraints, $t(28) = -5.95$, $p < .001$, and interlocutor pressure, $t(28) = -3.77$, $p < .001$, suggesting that the three factors were successfully manipulated and are the major sources that led to the difference between tasks.

Table 2. Means of self-perceived ratings on the three anxiety factors

	Attention level	Self-perceived language anxiety state
Task difficulty	2.45 (0.95)	3.48 (1.15)**
Time constraints	1.76 (0.74)	3.00 (1.04)**
Interlocutor pressure	2.14 (0.83)	2.79 (1.01)**

$^{**}p < .01$

4.2 Analysis of brainwave and self-perceived Language Anxiety

To examine if different types of tasks would lead to different attention level and language anxiety states, two paired t-tests were performed. As table 2 shows, there was no significant difference between the two conditions in attention levels, suggesting that both the classroom and real-world situated tasks lead to similar attention states. The means also showed that both groups obtained “neutral level” of attention states according to the eSense scale. In terms of language anxiety states, the real-world task significantly led to higher self-perceived language anxiety, $t(28) = -5.17$, $p < .001$, $d = .97$, indicating the real-world type of task is more anxiety inducing as expected.

Table 2. Means and standard deviation of measures by condition

	Attention level	Self-perceived language anxiety state
Classroom situation	50.72 (2.27)	2.70 (0.80)**
Real-world situation	47.89 (2.09)	3.41 (0.66)

$^{**}p < .01$

4.3 Correlation between brainwave and self-perceived Language Anxiety during language task

To examine the relationship between attention levels and language anxiety states in the two conditions, two Pearson Correlation analyses were performed. The results showed that, in the classroom practice condition (see figure 3), there was a negative correlation of -.36 between attention levels and language anxiety states, although the result reached marginal significance (p = .051). There was a positive correlation of .38 between the attention levels and language anxiety states (p = .04) in the real-world situated condition (see figure 4).

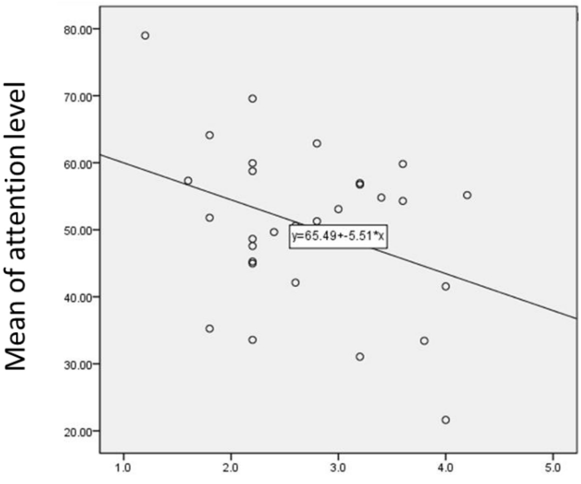

Fig. 3. Correlation between attention levels and language anxiety states in the classroom practice condition

These results suggest that in the classroom practice condition, learners who feel less language anxiety tend to pay more attention to the language task. Interestingly, in the real-world situated condition, it is the learners who experienced more anxiety language tend to better concentrate on the language task. Note that what differs between the two tasks are the degree of task difficulty, time urgency, and talking to a student partner or an English-speaking partner. One possible explanation for such divergent trends observed in the two conditions is that learners with lower anxiety are more able to adapt their attention when the anxiety induced by the task is moderate. However, when such anxiety reaches a certain level (higher than 3, the median figure of the scale, in this study), learners experiencing a higher level of anxiety might put more effort in paying attention during the language task. These findings echo earlier studies, which found that anxiety may facilitate performance where increased effort can compensate for the reduced efficiency of cognitive processing [4].

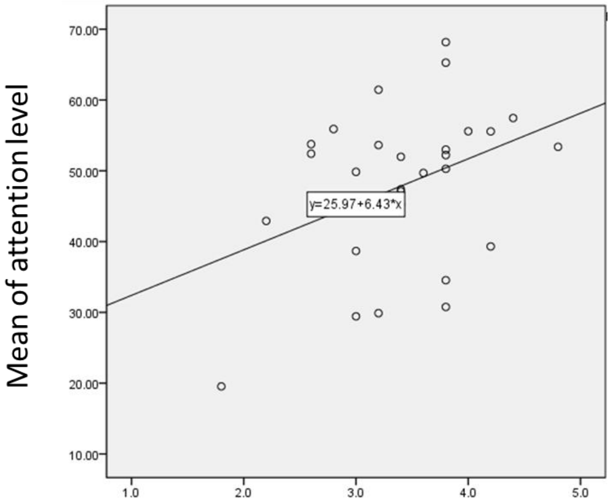

Fig. 4. Correlation between attention levels and language anxiety states in the real-world situated condition

4.4 Implications for educators and system developers

The results of this study can help language instructors better understand how different types of tasks can lead to varying level of anxiety and how such anxiety can correlate with sustained attention states. Specifically, when designing a language task, instructors should take into consideration how task elements, such as task complexity, time urgency, and interlocutor, can affect students who experience different levels of language anxiety in a way that potentially limits or enhances how they attend to the language task. When conducting a typical type of classroom language task, instructors might consider scaffold or facilitate students who experience high language anxiety. However, providing a more authentic task, or a more challenging one, might increase their attention to the task. This finding implies that lowering language anxiety might not always be beneficial for language learning. Certain extend of anxiety can lead to better attention to the task. For system developers, EEG headset can enable attention recognition during a language task. In designing technology integration, real-time attention recognition can be used to adjust learning content or factors related to language anxiety while learners feel anxiety during a language task.

Also, as conventional measurement of language anxiety is through self-report or questionnaire, the results are not real time. Future studies can look into the possibility of using a smart watch to monitor anxiety states as it has the potential to record hear rate variability, which has been found to link with one's anxiety [13].

5 Conclusion

This study attempted to examine how sustained attention states are associated with the self-perceived Foreign Language Anxiety in two commonly adopted language tasks, namely classroom and real-world situated practice tasks. Attention levels were measured using Neurosky's biosensor during the tasks. States of language anxiety were measured using questionnaire after the task. Results showed that the two tasks did not lead to significant difference in the attention levels but the two tasks led to different levels of anxiety. Further analysis showed that on-task attention level was negatively correlated with self-perceived language anxiety in the classroom practice condition. In the real-world situated condition, on-task meditation level was positively correlated with self-perceived language anxiety. Findings suggest that while students with low anxiety tend to sustain better attention during the language task, their attention can be enhanced when they feel more anxiety resulting from a more challenging task. Note that the participants of the study are considered intermediate high language learners for their average percentiles of English scores are high, which makes the results only generalizable to those at similar proficiency level. Finally, we will continue to explore how attention level measured during a language task is related to actual learning outcomes as well as whether attention level can be used as an index for guiding real-time adaptive mechanism. It is hoped that this study can contribute to the field of technology-enhanced language by identifying potential learner variables involved in a language task.

6 Acknowledgments

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A review of using Augmented Reality in Education from 2011 to 2016

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Abstract. In recent years, there has been an increasing interest in applying Augmented Reality (AR) to create unique educational settings. This paper reports a review of literature on augmented reality in educational settings considering the factors include the uses, advantages, features, and effectiveness of augmented reality in educational settings. In total, 55 studies published between 2011 and 2016 in Social Sciences Citation Index database were analyzed. The main findings from this review provide the current state of the art on research in AR in education. Furthermore, the paper discusses trends and the vision towards the future and opportunities for further research in augmented reality for educational settings.

Keywords: Augmented Reality, literature review, trends of Augmented Reality

1 Introduction

In the past two decades, the applications of augmented reality (AR) have been increasingly receiving attention. AR was first used in the 1990s, when applications were related to the training of pilots[1]. According to the 2011 Horizon Report, AR, with its layering of information over 3D space, creates new experiences of the world, and suggested that AR should be adopted in the next 2–3 years to provide new opportunities for teaching, learning, research, or creative inquiry. AR takes advantage of virtual objects or information overlaying physical objects or environments, resulting in a mixed reality in which virtual objects and real environments coexist in a meaningful way to augment learning experiences [2][3]. There is a large volume of published studies that report advantages, limitations, effectiveness challenges, etc. of AR in education. However, since AR is an emergent technology, it is important to get an overview of the advances and real impact of its use in educational settings, describing how AR has been used for generate more student-center learning scenarios. In this study, we review empirical

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studies that have employed the augmented reality technology in education. The analysis may help to construct a framework revealing the current state of the augmented reality technology in education.

2 Method

The literature source for this review was the Social Sciences Citation Index (SSCI) database, one of the highly recognized databases indexing core journals in the social sciences. The time span was set from 2011 to 2016, and the document type was limited to journal articles in an attempt to review studies of potentially more consistent quality. We used the keyword "Augmented Reality" for searches, and 55 papers were identified as the research sample pool of this review. Content analysis[4] was applied in order to extract the information of each paper. We analyzed and classified sample groups, major contributing countries, subject domains, type of AR, the research methods involved (qualitative, quantitative, mixed, system design and review paper) and effectiveness of AR in the 55 papers in this study. Two of the authors of the paper manually coded the studies separately according to their characteristics and classified them according to the categories and sub-categories defined.

3 Results and discussion

3.1 Number of papers published

Among the 55 AR studies, only 8 were published in 2011 and 2012, while 12 of them were published in 2013, and 18 were published in 2014. According to these results, AR in education is an emerging topic and the research on AR in education is in the initial phase[5] [6]. In 2013, Bujak[7] point out: "Augmented reality (AR) is just starting to scratch the surface in educational applications."

3.2 Number of Journal Publications in this review

In total 55 studies were analyzed from the 10 journals, include that Computers & Education (17), Computers in Human Behavior(11), Journal of Science Education and Technology (6), British Journal Of Educational Technology(5), Educational Technology & Society(4), Interactive Learning Environments(4), IEEE Transactions on Learning Technologies(3), International Journal of Computer-Supported Collaborative Learning(3), Journal of Computer Assisted Learning(1), and Journal of Educational Computing Research(1).

3.3 Major contributing countries in this review

The Taiwanese authors contributed the most publications (22) followed by Spanish authors (12), US authors (9), Chinese authors (2), Switzerland authors (2) and Turkey authors (2).

3.4 Sample groups in this review

Regarding the "Target group," this category refers to the level of education of participants in the experiments in which the study of AR in education was carried out. First, it is worth noticing that AR has been mostly applied in higher education settings (Bachelor, 23.64%) and compulsory education (primary, 16.36%; Junior school, 18.18%). Most of the studies reviewed in these target groups applied AR for motivating the students, explaining topics, adding information and other purposes that are discussed later. It seems possible that AR has been applied in settings with this target group in order to improve the educational experience of the students and motivate and engage them by taking advantage of the features of this technology. In the studies reviewed there were few AR applications in the field "Early childhood education" (5%).

3.5 Research field in this review

It is indicated that 40.0% of the 55 papers report on studies in field of "Science", which is the most studied domain in the use of augmented reality by each field of education. This may be because AR has demonstrated to be effective when adopted in lab experiments[8], [9], [10], mathematics and geometry[7], [11], [12], geography and ecology[13], [14], [15], [16], scientific issues[17], [18], [19]. It can concluded that AR is effective for activities where students learn things that could not be seen in the real world or without a specialized device, and learning abstract or complex concepts. In addition, 16.36% of the AR studies focus on Social Science courses. Studies in this field focused on language learning[20], [21], [6], visual art and painting appreciation[22], [23]. AR has been widely used in Social Science due to the possibility of augment information and combining it with contextual information to provide new experiences. Also, those in the education field also explored and investigated the effects of AR in "Engineering, manufacturing and construction (14.55%)", "Health (7.27%)" and "Service (7.27%)."

3.6 Research methods and design in this review

As for the research type of in the selected AR studies in education papers from 2011 to 2016, it is shown that the most employed is experimental design and quasi-experimental design. The most frequently used of research methods is mixed methods (40.0%), followed by quantitative research methods (32.73%) and qualitative research methods (7.27%). In addition, some papers just focused on review of the literature and system design, which did not involve the methods mentioned previously. For "Data Collection methods", most of the studies applied

"Test" (47.27%), especially some studies of these adopted pre-test and post-test (29.09%). " Interviews" (30.91%), "Questionnaires" (29.09%), "video observation" (18.18%) and "surveys" (16.36%) as data collection methods. "Writing Essay" (1.82%) have used very little. Since one study can apply more than one data collection method this study counts for more than one category. In the aspects of participant, most of the studies used medium research samples "between 30 and 200" and some studies considered small research samples "30 or less than 30". In our review we find a few studies that used research samples greater than 200 participants. And the research time dimension is almost cross-sectional, only a few are longitudinal Study. In these 55 studies, the image-based AR is used more than the location-based AR, and AR of educational settings usually applied in classroom. However, it can adopted in museum[23], [11], library[24], and field trip[13], [25]. The treatment of AR in education is commonly smartphone and tablet. In Giard's[26] study, Oculus Rift glasses is mentioned, and we think it may become the important research object of AR in the future.

3.7 Effectiveness of using AR in this review

The major advantages of AR in these studies reported are learning gains and motivation. In these 55 papers, most of studies reported that AR in educational settings lead to better learning performance and promoting learning motivation, which because AR supply the authenticity graphical content and interaction. Also, deeper student engagement, improved perceived enjoyment, and positive attitudes of AR are reported as the effectiveness of using AR.

4 Trends and future vision

In the future, some recent studies have reported new research directions, for example, We suggested that larger sample sizes and extensive subject matters need to be concerned[15]; We recommend lengthening the research timeframe and mixing the teacher requirements with the developed van Hiele's level of geometric reasoning test, under the assumption that it will contribute to the acquisition of more comprehensive data[12]; Additional interactive strategies (e.g., games and role-playing) can be incorporated to enhance the first-hand experiences and interactions of users[27]; To enhance reality and magical sense for EMT, smart glasses can be used when playing toys[28].

View from these papers, we conclude that more studies need to be undertaken considering the difference of cognitive process and psychological immersion between AR and reality settings; the individual interaction, sense of identity, and adaptive application in augmented reality; AR classroom design and evaluation research; the teacher's role model in AR educational setting; designing and implicating learning resources of AR in k-12.

5 Conclusions

In this paper, we reviewed the empirical AR studies in educational settings published in SSCI-indexed journals from 2011 to 2016. The researchers in this study found that the number of AR studies in education has significantly increased since 2013. Authors from the Taiwan, Spain, and USA contributed most AR studies in education that were conducted during 2011 to 2016. In addition, the authors found that more and more empirical studies were carried out on Science, as well as on social science and Engineering. Furthermore, the quantitative research method was used more often than other methods in AR research in education in the past 5 years. Finally, we expect that the findings in this study could reveal the importance of the adoption of effective AR in education, and provide potential directions for future research.

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A New MOOCs' Recommendation Framework based on LinkedIn Data

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Abstract. We propose a new framework for recommending *Massive Open Online Courses (MOOCs)* to lifelong learners. Our approach can be summarized in two steps: (1) recommending *MOOCs* to potential learners according to their curricular information by relying on their *LinkedIn* profiles, and (2) recommending topics of interest to *MOOCs*' providers by considering the job market needs. We also provide some insights about *MOOCs* of our *Coursera* dataset, thus to be taken into account during the decision process.

Keywords: MOOCs; Recommendation System; Collaborative Filtering; LinkedIn; Coursera.

1 Introduction

The emergence of *MOOCs* [1] as a new learning alternative came with new challenges to the *educational technologies* research field. The diversity and abundance of these learning items (due to the number of providers, topics, tuition language, etc.) generates complexity for some lifelong learners: while some of them could select courses directly from *MOOCs* platforms (or even via *MOOCs* aggregators), some others would need to be supported by relying on an accurate knowledge about the job market. In this context, we assume that more personalized *MOOCs'* recommendations can improve learners' completion rates [1], allow them to earn new demonstrable skills (recognized certifications), and improve their respective careers' paths (aspire for new job positions, better salaries, etc.).

So, our contribution here consists in describing a new framework of MOOCs' *Recommendation Systems (RSs)* based on LinkedIn data. This *RS* takes advantage of *public* information conveying on social media and *MOOCs* platforms, thus with respect to users' privacy and data integrity (we follow a data minimization policy [2]). Furthermore, with its 18 million learners worldwide announced in April 2016 [3], *Coursera* stands at the top of the *MOOCs* providers.

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So, before focusing on other MOOCs platforms (*Edx*[1], *Udacity*[2], etc.) , we provide some insights about our own *Coursera dataset (CD)*.

This paper is organized as follows: in the next section, we describe our dual *RS*-based framework: (1) the *Topics_Rec* for MOOCs providers and (2) *MOOCs_Rec* for lifelong learners. In section 3, we provide more details about our *Coursera dataset (CD)* and describe our ongoing and future works.

2 Proposed Approach

This new framework combines two recommendation systems. The first one – *Topics_Rec*, aims to recommend new topics to *MOOCs* providers by considering the job market needs (open positions advertised on social media). The second system - *MOOCs_Rec* recommends MOOCs to lifelong learners by taking into account **(1)** the target learner's profile, **(2)** profiles' description of the nearest professional field, and **(3)** description of the available *MOOCs* offers.

Obviously, the recommended *MOOCs* (via *MOOCs_Rec*) take into consideration the learner's profile, but also the job market needs as a direct result of the use of *Topics_Rec* (Fig. 1).

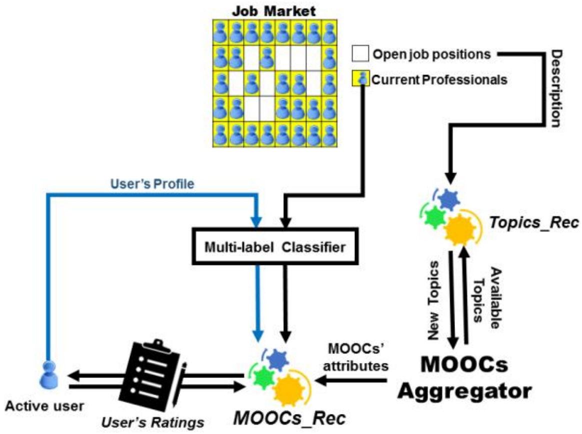


Fig. 1. General Schema of our MOOCs Recommendation Systems Framework

2.1 Topics Recommendation System (*Topics_Rec*)

The *Topics_Rec* system is a *keywords*-based visualization tool that aims to propose new topics according to the job market needs. Therefore, since the job demands are *context-dependent* (*location*, *language*, etc.) and constantly changing

1 www.edx.org
2 www.udacity.com

over time, MOOCs providers would benefit from the adaptability of the proposed tool. Therefore, *Topics_Rec* is based on a *corpora*-subtraction technique: (1) description of open job positions from (2) description of available *MOOCs*. In this sense, the remaining *corpus* (blue region in Fig. 2) will be used to generate *tag clouds* [2] for each of the identified topics.

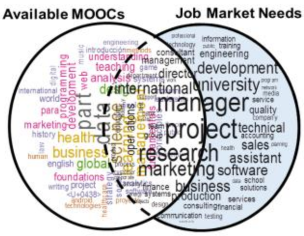


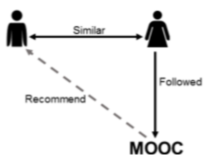
Fig. 2. *Topics_Rec* tags-based subtraction scheme

The *Topics_Rec* considers the description of available *MOOCs* and their associated topics. In this context, a prior classification is performed (i.e. *Coursera dataset* in section 3). Furthermore, we are detecting job Ads conveying on social media (e.g. *LinkedIn*) and classifying them into their professional categories.

2.2 MOOCs Recommendation System (*MOOCs_Rec*)

The *MOOCs_Rec* is a feature that forms part of our *MOOCs' aggregator*. It aims to return a list of *top-N* recommended MOOCs by taking into account the LinkedIn data of the *Active User (AU)* but also his interactions on the aggregator's platform (ratings of the recommended *MOOCs*).

To do so, we apply a *model-based Collaborative Filtering* (CF) technique [4] by developing a pre-computed model. The idea behind this technique resides in the fact that the more similar two users are (based on their *attributes/features*), the more they have common interests (Fig.3-a). The *neighborhood formation* is made by using a *multi-label classifier* (Fig.1) that assigns to each profile a set of professional fields. So, the more labels two users have in common, the more similar they are (Fig.3-b). In this context, professionals who exhibit their MOOCs *verified certificates* on LinkedIn will serve as a knowledge base for our recommendation system (Fig.3-c).



(a) Collaborative filtering

	Tech.	Business	…	Edu.
U_1	0	0	…	1
U_2	1	0		1
.				
.				
.				
U_{n-1}	1	0		1
U_n	0	1		0
A.U	1	0		1

(b) *Profile-Field* (PF) Binary Matrix

	$MOOC_1$	$MOOC_2$	…	$MOOC_n$
U_1	-	-	…	1
U_2	1	1		-
.				
.				
.				
U_{n-1}	-	1		1
U_n	1	-		-

(c) *Profile-MOOC* (PM) Matrix

Fig. 3. *Collaborative filtering* for the *MOOCs_Rec*

3 Discussion and Future Works

We have presented a new framework for recommending new topics to *MOOCs*' providers (*Topics_Rec*) but also *MOOCs* to lifelong learners (*MOOCs_Rec*). In this context, we have detailed the interactions between the different components of this framework. Furthermore, we have already collected and characterized *LinkedIn* profiles in [2]. We have also implemented and validated a *Support-Vector-Machines (SVMs)*-based *multi-label Classifier* that associates a set of labels (professional fields) to users by taking advantage of their LinkedIn data.

Therefore, we have automatically collected details about *MOOCs* on *Coursera*, thus to be taken into account in the recommendation process. To do so, we have used the *Coursera Application Programing Interface (API)*. A total of 1674 *MOOC* has been gathered. In this sense, the distribution of *MOOCs* among domains/topics shows that a majority of 21,21% are *business* oriented, 15,16% belong to the *social science* category, 14,88% to *computer science*, etc. It is worth to note here that this dataset is *multi-labelled*, i.e. a given *MOOC* may belong to different domains in the same time (e.g. "*CODAPPS: Coding mobile apps for entrepreneurs*[3]" belongs to both *computer science* and *business*). Furthermore, 15 different languages are used for these MOOCs: with its 75,55%, English is largely used as a primary language, 8,84% are in Spanish, 2,69% in French, 0,18% in Arabic, etc. In addition, MOOCs on Coursera may be subtitled. So, we have identified a total of 35 languages distributed over 325 different MOOC. Also, 34,1% of Coursera MOOCs are within *specializations*, 58,86% may lead to a *verified certificate* and only 2,86% end with a *statement of accomplishment*.

Finally, we are working on the implementation of a *MOOCs' aggregator* that aims to capture users' interactions with the recommended MOOCs: *added to the wish list, not interested in, completed*, *recommended to a friend*, etc. These new weighted features will enrich the *Profile-MOOC matrix*. So, it aspires to offer more accurate and personalized recommendations and to validate the *MOOCs_Rec* by maximizing the satisfaction/completion rate.

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Towards a Smart University through the Adoption of a Social e-Learning Platform to Increase Graduates' Employability

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Abstract. The current paper proposes the improvement of the smart university model, defined as a set of highly technical interrelated elements, by implementing a social learning platform within the university ecology. This platform should permit the collaboration of various stakeholders – students, professors, university representatives and companies and should increase the visibility of the most meritorious graduates. In this paper, the research methodology applied to check the feasibility of the concept is presented, as well as the results obtained from the various structured interviews and online surveys conducted mainly in Danube Region countries.

Keywords: social learning; employability; smart university; university ecology

1 Introduction

The multitude of online resources, the easy access to them, as well as the raise of new technologies, such as highly cognitive computing systems, big data, social and semantic web, virtual reality reshaped the learning processes, stimulating new paradigms of learning, e.g. lifelong learning, ubiquitous learning, learning at work or learning at home [1]. The widely spread of these learning paradigms has a great impact on formal learning as well: the model of smart university was introduced,

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as a set of elements which “accelerate the knowledge acquisition”, elements which are based on cutting edge technologies [2]. A so-called smart university has to sustain opinion mining, in-depth analysis of various stakeholders’ needs, creation of a strategic vision that can be structured based on goals and quantified in key performance indicators, prioritization of goals and alignment to well-known standards of competences, such European e-Competence Framework (ECF), all sustained by monitoring and analytics tools [2]. The final purpose of a smart university is enhancing universities’ efficiency, facilitating the rapid growth of knowledge [2]. In a study made by UNESCO [3], education efficiency is divided in internal efficiency, which “measures the output and outcome of the education system” – the set of competences acquired in university and external efficiency which measures the extent to which those competences become economic and social benefits. More concrete, private and social rate of returns of education and statistics related to graduate unemployment are considered indicators for quantifying educational efficiency. We embrace the model of smart university, as a set of highly technical interrelated elements, but we go further and state that the ultimate goal of the model should be to increase students’ employability, by facilitating their continuous interaction with possible employers. In order to implement such a model, a social learning platform should be introduced within the university ecology – its concept was presented by us in a previous study [4]. In this paper, we debate the results of a research conducted to test the feasibility of the concept using mainly the Danube Region (DR) countries. The methodology of the research, the results and their interpretation are further described, in the context of IT-supported solutions for enhancing the graduates’ access to labor market.

2 IT-supported solutions for increasing the graduates’ employability

Socializing e-Learning. Learning management systems (LMS) are not a new tool anymore. Students are more communicative on social networks than on a LMS forum, thus many universities have made pages on the most used social networks or, even more, develop their own customized social networks, which facilitate not only the access to learning material, but also the knowledge exchange [1]. Virtual learning communities (VLC) are also well-known IT-supported solutions for learning which highly exploit social interactions between users [6]. The positive correlations between the learning process and the social presence in a community of practice, which is an instantiation of VLC, are highlighted in [7]. Many users of social e-learning instruments are aware of the value of “learning by interacting” and find social networks, VLC or LMS with social media integration as opportunities not only to increase one’s knowledge, but also to make their competences visible to others, including potential employers [4].

Socializing e-Recruiting & Job Searching. Society for Human Resource Management, the largest Human Resource membership organization, ran a survey with more than 400 human resource professionals during November-December 2015, with the purpose of finding about the methods applied for recruiting and screening job candidates [8]. The role played by social networks is tremendous: 84% of the companies currently use them and 9% of companies plan to use them in the near future, while only 56% of the companies used social media for recruitment in 2011; the following social networks are considered to be the most powerful online recruiting channels: LinkedIn (96% of companies used LinkedIn and 73% of them declared it as the most effective social media site), Facebook (66% of companies used it) and Twitter (53%). A wide range of social media-based recruiting tools are also available [9]: Jobvite,Talent Xray, Workible, Lippl, Facebook Marketplace, BranchOut, which turns Facebook into LinkedIn by overlaying employer information on top of users' Facebook interface. More recent studies, such as [10] and [11] are focused on the applicant personality in an online recruitment system and claim that already existing e-recruitment platforms are not assessing personality traits.

Although there are numerous attempts to exploit social technologies both in learning and in recruiting/searching for a job, they are not always directly correlated with each other or to a university environment. We claim that embedding them into the learning ecology of a university will increase the employability level of students/ graduates and, consequently, the efficiency of that university, making it smarter. In order to test the validity of this concept, we conducted a transnational research, focusing especially on countries from DR.

3 Research Methodology

Based on the premises that social learning is a necessary element in a smart university, increasing its performance, in general, and the employability of its graduates, in particular, we conducted a transnational research, focusing mainly on DR countries, due to the strategic value of this European area [12]: see Fig. 1.

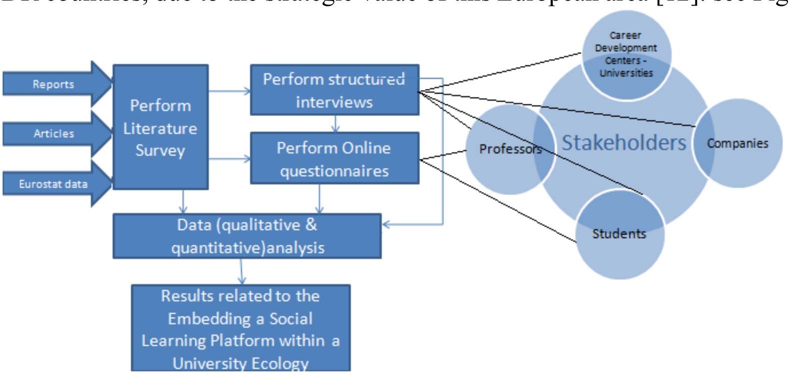

Fig.1. Applied Research Methodology

We limited our study to respondents from IT-related domains. All the structured interviews took place in parallel in Romania, Austria and Serbia, during February 2016, while the online surveys were advertised on social media and within internal networks of collaborators from DR countries from 1st of March 2016 to 4th of April 2016. In the end, we applied data triangulation between the responses received from several stakeholders, to obtain the features which will make a social learning platform to be accepted in the current university ecosystem.

4 Analysis of Research Results and Discussions

Structured Interviews. We had 21 respondents, from all groups of stakeholders – professors, students, representatives of a university Career Development Center (CDC) and companies from countries situated on different areas of DR and also having different development levels [12]. The interviews with students revealed the perceived importance of LMS and the wide extent of social networks in their learning activities. The professors acknowledged the importance of social networks, as a source of communication with their students and the benefits brought by a LMS. The representatives of companies enumerated their recruiting methods: online recruiting via LinkedIn, holding job fairs, college recruiting (student internships & scholarship programs), peer recommendations and the classic word to mouth, visiting universities for juniors or using enterprise social network (Yammer). CDC enumerated several activities they do for helping students (companies; presentations, workshops), but unfortunately they admitted they don't have enough visibility.

Online Questionnaires. The online questionnaire for students had 394 respondents, but only 391 were finalized and validated, while the online questionnaire for professors had 59 respondents. We had respondents from Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Romania, Serbia, Slovakia and a few from other DR countries as well (13).

Most of the students who answered our questionnaire had a job experience related to their university specialization (88.9%). At the question "In what extent did the didactical activities support you to get a job?", almost half of the students chose 3 out of 5, almost 30% chose 4 and 5, while the rest chose 1 and 2 (1-not at all, 5- in a very much extent). 74.4% of the students stated that collaboration between universities and companies will increase their success in employment. Regarding their online presence, 82.1% of the students were active on social networks, from which 97.8% on Facebook and 54.8% on LinkedIn, but only 26.6% of them were members of a professional e-community. Professors are less involved than the students in social networks. Furthermore, only 24.8% of the students said they use a LMS in their classes, fact that it is surprising for the current period. Almost 90% of the students are convinced or almost convinced that the usage of a

LMS could be a potential improvement in gaining employability: the question is then why don't they use it, as so many LMS are available nowadays. On the other hand, 55.9% of the professors use LMS in their classes. When asked whether a social learning platform would have considerable enough benefits to the employability level in DR, 88% of the students said yes and 78% of them would like to have direct contact with companies through this platform, stressing once more the importance of companies-university relationship.

An important part of our research revealed the functionalities considered necessary both by the student and professors: direct contact of companies within the platform, virtual labs, advanced learning analytics, integration with university LMS, integration with other social networks, alumni monitoring. These features can't be sustained unless advanced technologies (e.g. social technologies, ontology-based recommendations, big data, virtual reality) are exploited.

We tried to identify dependencies between various variables in our research, thus we used the Fisher statistical test and obtained the following results: (1) The relationship between the level of education and use of social networks was analyzed: the p value was 0.0006335. Interestingly, most educated students do not use social networks (2) The relationship between the level of education and the answers to the question "Do you have a job experience?" was investigated: the p value was 6.328 * 10^(-13). Along with the education level, the percentage of the survey participants who have job experience also increases. (3) The relationship between the level of education and the answers to the question "In what extent did the didactical activities support you to get a job?" was inspected: the p value was 0.005218. Those who have a higher level of education believe that education has helped them in a larger extent to get a job.

5 Conclusions and Recommendations

The current paper presents the results of a research regarding the feasibility of a social learning platform concept, in which various users should interact. This platform should be integrated in the university ecology, using cutting-edge technologies, thus transforming it into a more efficient university, a smarter one, in which graduates will be in continuous contact with companies and their academic performance will be visible to possible employers. Most of the participants in our research were positive about the success of such a platform. We also noticed that although students ask for a stronger collaboration between universities and companies, they don't use or know the career services which are provided by universities. Thus, a reshaping of those services is needed and, maybe, a clearer integration of them into the university LMS. Students are very active on social networks, but not so active on LMS, thus using the current social networks or just featuring LMS with social flavor will increase the interests of students towards LMS. The perceptions of professors and students regarding activities which increase the employability is slightly different, consequently an analytics module is necessary and a clear presentation of the analytics results, both for students and professors, is also mandatory. In order to implement all the functionalities considered useful both by students and by teachers, a mix of recent technologies is advisable. The participants in our study were mainly from DR, but we claim the study is world-wide valuable, especially for countries with a high unemployment rate.

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A 3-D Educational Game for enhancing learners' performance in A star Algorithm

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Abstract. Many recent studies have reported the efficiency of educational games in making learners motivated and active while learning. At the same time, many studies as well have reported the difficulties of learning Artificial intelligence algorithms such as A star algorithm. Therefore, this paper presents a newly developed educational game which aims to help learners learn A star algorithm in a fun, interactive and easy way.

Keywords: Artificial intelligence; A star algorithm; educational games; computer science.

1 Introduction

Many studies have highlighted that mixing both playing and learning processes can enhance the learner's motivation while learning [1]. Consequently, educational games have started gaining an increasing attention from researchers and practitioners. In these games, learners are situated in a gaming scenario to complete a series of learning tasks individually, collaboratively, or even competitively [2].

At the same time, Artificial Intelligence (AI) has started to be used in different fields (education, medicine, etc.). It is a subpart of computer science which consists of making computers be able to perform the thinking tasks that humans are capable of [3]. One of the covered topics by AI is "search algorithms" in particular A star (A*) algorithm. However, many studies have reported the difficulty of learning artificial intelligence algorithms [4]. In addition, and from a practical experience, learners found learning A* algorithm using the traditional method in classrooms hard. Besides, many educational games with different pedagogical objectives for computers and mobile devices [5, 6] were reported in the literatures, but none of

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them focused on teaching A* algorithm in a fun and motivating way. Therefore, the main research question that this paper aims to answer is *Does the use of an educational game enhance the learners' performance in learning A star algorithm?*

In this context, this paper presents a newly designed 3D educational game called *A* game*. The rest of the paper explores the proposed research question as follows: section 2 starts by presenting a literature review regarding educational games and artificial intelligence. Section 3 presents the newly developed educational game to learn A* algorithm. Finally, section 4 concludes the paper with a summary of this research and some future directions.

2 Literature review

This section presents a literature review regarding educational games and their advantages as a learning tool. Besides, it explains the A* algorithm.

2.1 Educational games

Educational games were defined as applications using the characteristics of video and computer games to create engaging and immersive learning experiences with specified learning goals [7]. These games provide challenge tasks, encourage different levels of interaction, and provide enjoyable multimedia and instant feedback [8, 9]. Besides, they can be used to model learners and gather information about them [10]. Furthermore, educational games can make learners more active in discovering new ideas, information, and solutions of given problems [11]. Many of them are designed with different pedagogical objectives, such as computer architecture and programming skills training. However, none of the educational games currently aims to teach AI, in particular A* algorithm.

2.2 A star algorithm

To solve different problems, learners need to get a strong understanding of the way search algorithms work [12]. However, many studies have proven the difficulty of learning AI algorithms [4]. In particular, and from a practical experience, learners usually require a lot of concentration and mental effort to solve A* algorithm problems. Besides, they find learning A* algorithm using the traditional method in classrooms difficult and not motivating. Therefore, new learning methods for teaching this algorithm are needed.

In this context, the next section presents a newly designed 3D educational game which aims to help learners learn A* algorithm in a fun, motivating and easy way.

3 A*Game

To allow learning A* algorithm in an easy and motivating way, a 3D single player educational game called *A* Game* is designed. According to [13, 14], 3D graphics offers a better learning-playing experience, by using realistic graphics, sounds and addictive story lines. Besides, different game elements are implemented in *A*Game*, such as avatar and game objects.

In the game, the learner has to find the shortest path to the destination where a diamond is hidden. To do so, *A*Game* proposes a map, using Unified Modeling Language (UML) class diagram, where the learners can get information about all the possible paths and follow the shortest one to get to the destination. Each time the learner goes through a node, an immediate feedback, which is the execution of both the *Open* and *Closed* list will appear. This can help the learners to know if the visited node is correct or not. In particular, if the visited node is correct, it will be colored on the map. Consequently, the learners can visualize in a global view the traces of the shortest path, which is colored in the graph, hence organize what they have learned during the gaming.

To increase the challenge during the game, different enemies that the learner can encounter are implemented. These enemies will try to make learners change their taken path or lose before they achieve their destination.

Figure 1 presents a snapshot from the *A* game* interface where it is divided into two parts: the game environment and the game map.

Fig. 1. Snapshot from the game interface

4 Conclusion and Future directions

This paper presented a newly designed educational game entitled *A* game* for teaching A* algorithm in a fun, interactive and motivating way. Future research directions will focus on validating the efficiency of this game through different experiments. Besides, they will focus on investigating the impact of using the embedded UML class diagram (see figure 1) as a standardized concept map in the game.

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A 3D Learning Game for Representing Artificial Intelligence Problems

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Abstract. In recent years, there has been growing interest in 3D educational games. This is due to the confidence that 3D environment can offer several learning benefits to learners. Specially, 3D educational games focusing on Artificial Intelligence (AI) are needed today. In particular, problem representation by state-space approach is seen as an important part of problems solving for learners. So, developing 3D educational games which enhance learners' motivation for the AI subject is the main issue of this work. In this context, this paper presents a 3D educational game for higher education. This new game is called Bridge Crossing Game and it allows learners to benefit from the 3D environment to solve Bridge Crossing Problem in an amusing story.

Keywords: Educational Game, 3D Environment, Problem Representation

1 Introduction

Learning AI faces the problem of low motivation of students. This is due to the complexity of this subject and the diversity of students' backgrounds [1]. In fact, most students study AI course at the end of curricular [2]. In fact, before this course, they need to have some basic skills of programming. However, many students have a difficulty in understanding problems solving, even students who previously had little trouble with the basic data structures.

On the other hand, many researchers have stressed the importance of problem representation in problem solving process. Some of them considered the problem representation as a cardinal point [3]. Some others considered it as a key to problem solving among novice learners and experts [4]. Thus, to solve a problem the learner needs to understand that problem and then represents it as a state space. The students find the process of solving AI problems so difficult and so incredibly boring because it requires a lot of effort from them. . For instance, Bridge Crossing Problem (BCP) is one of famous AI problems that have been around in many incarnations and with various anecdotes attached to it, and her history has explored

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by Torsten Sillke that assembled on his web page [5]. So, the teaching process of BCP needs today a learning environment that is interesting and stimulating for learners [6] to increase learner's motivation and engagement during problem solving process.

Among learning environments, 3D environments offer new opportunities for learners to learn through exploring environments in relatively open-ended ways [7]. Therefore, 3D environment facilitates the learning of the individual steps of a problem solving representation. In addition, the use of computer games is an interesting alternative to reinforce learning experience since it can render education more motivating and engaging and can keep learners more interested in learning [8]. In particular, a new generation of learners, called Game Generation [9], spends a significant amount of time playing computer games. In view of these, *do 3D games help learners in AI problem representation?*

To answer this research question, we develop a serious game called Bridge Crossing Game (BCG) to help learners' in AI problem representation. Also, our educational game is designed to render the difficult process of learning AI problems engaging, motivating and more amusing. BCG allows learners to have the opportunity to play a 3D game, which enables them to learn while playing.

This paper is structured as follows: Section 2 contextualizes the contribution by analyzing related works. Section 3 presents the move from Bridge Crossing Problem to Bridge Crossing Game including elements of effective educational game design. Finally, section 4 concludes the paper with a summary of the work.

2 Related Works

Researchers have demonstrated the effectiveness of educational games in many domains such as Language Learning, and Math. Table 1 presents examples of 3D educational games and their pedagogical objective.

Table 1. The Effectiveness of 3D Learning Games in Different Domains

Pedagogical Objective	3D Educational Game
Language Learning	Tactical Language training System [10]
Math	Ring [11]
Ecology	CMPRPG [12]
Geography	VR-ENGAGE [13]

As it is shown in table 1, many 3D educational games are used in different domains (e.g. education and security) such as:

Language Acquisition teaching, the Tactical Language training System [10] is designed to help people rapidly acquire basic spoken conversation skills, particularly in languages that few foreigners learn because they are considered to be very difficult. Each language training package is designed to give people enough knowledge of language and culture to carry out specific tasks in a foreign country such as introducing yourself, obtaining directions and arranging meetings with local officials.

In Ring [11] game, students are presented with a set of rings in the water and are challenged to try to swim through as many as possible with one mathematical function.

CMPRPG [12] is used for teaching notions of dynamic ecosystem equilibria. Notions of dynamic ecosystem equilibria are applied to given situations: prey and predator. Notions of rupture of the ecosystem equilibria by natural factors are applied to given situations. In each situation, players have to collaborate in groups to find a solution for the situation.

VR-ENGAGE [13] is used for teaching geography. In VR-ENGAGE, The ultimate goal of a player is to navigate through a virtual world and find the missing pages of the book of wisdom, which is hidden. To achieve the ultimate goal, the player has to be able to go through all the passages of the virtual world that are guarded by dragons and obtain a score of points, which is higher than a predefined threshold. The total score is the sum of the points.

3 From Bridge Crossing Problem to Bridge Crossing Game

3.1 Elements of Effective Educational Game Design

Many researchers found that narrative context is an important element of effective educational game design. According to Dickey [14], narrative contexts offer learners, "a cognitive framework for problem-solving because the narrative storyline in games provides an environment in which players can identify and construct causal patterns which integrates what is known (backstory, environment, rules, etc.) with that which is conjectural yet plausible within the context of the story". Another significant element of effective educational game design is concerning the goals and rules of playing [15, 16]. Although they are integrated within a narrative context, goals and rules are not subordinate to context; they are equally important elements of it.

3.2 Bridge Crossing Game (BCG)

Our new game BCG is designed with 3D technology for educational purpose. It provides a 3D environment for learners to solve the bridge crossing problem and to build a state-space associated to that problem.

Game Story. The transmission of learning content in the form of a narrative game story is very important for learner [14, 17]. In this way, the bridge crossing problem statement is transmitted in the form of a narrative game story where learners have the chance to explore it in real context and learn by playing the BCG.

The story of BCG incorporates four persons on a plane which its fuel ends near an island. The main goal of the game is to help the 4 persons navigate through the island and to find a solution to leave. To do that and based on a wise old man advice (non player character), these 4 persons have to find and cross an old bridge (bridge problem). The game design (3D environment) and the story aim to make the learners more immersive while solving the problem. Besides, it aims to make learners live this learning experience.

Goals and Rules of Play. When they find it, the game interface will be divided in two parts; the first part concerning the game space and the second one concerning the problem representation (Fig. 1).

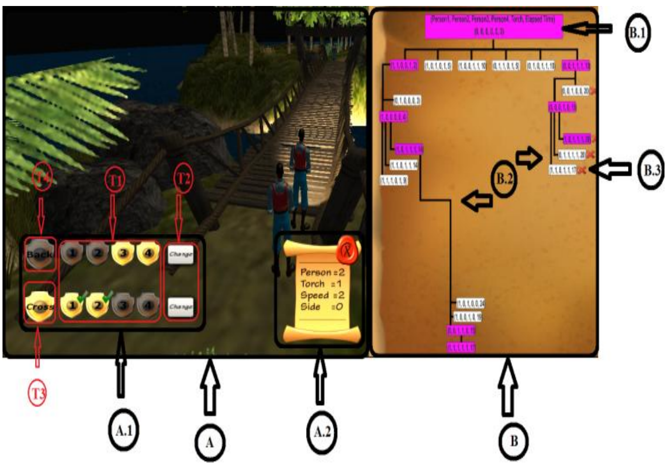

Fig. 1. The bridge crossing game (BCG)

Fig. 1 presents the interface of the BCG. This interface contains two principle parts (A and B), the part A includes two sub-parts (A.1 and A.2) and the B includes three sub-parts (B.1, B.2 and B.3).

Part A. This part holds the elements of game such as the four people, the bridge, the torch and an island design in which the learner should move people from the left side to the right side of the bridge. The sub-part "A.1" contains four types of button (T1, T2, T3, and T4) that help learners to play easily.

In T1: The "1", "2","3"and"4" buttons means that the chosen persons are respectively number 1, 2, 3 and 4. And, when the learner clicks on one button from T1, some information must be displayed in the sub-part "A.2":

- The person's number (1, 2, 3, 4),
- Person's maximum speed (1min , 2min , 5min , 10min),
- Person's side ("=0" if in the left side and "=1" if in the right side),
- Person's torch ("=0" if the torch is not with it "=1" if the torch is with it).

T2 contains the "change" button in witch learner can change people chosen in T1. In order to move them to the right side of the bridge, learner clicks on the 'Cross' button (T3) and click on the 'Back' button (T4) to move people from the right side to the left side of the bridge. After each crossing, all possibilities of the next step in the game are displayed in the part B in which learner solves the problem by playing and in the same time learns how to represent the problem by the state-space approach.

Part B. This part holds the representation of the BCP by state-space approach. The state space is the set of all states reachable from the initial state, it forms a graph (or map) in which the nodes are states and the arcs between nodes are actions.

All states hold 6 ordered variables (person1, person2, person3, person4, torch, elapsed time), the 5 first variables are binary ("=0" if person/torch is in the left side of the bridge and "=1" in the reverse), the last variable is an integer conserved the elapsed time that helps the learner by guiding him/her to the solution. Each state visited by the learner is colored by the roze color to help him/her to know the path towards the solution.

The sub-part "B.1" presents the initial state (0,0,0,0,0,0) linked by all possible next states {(1, 1, 0, 0, 1, 2), (1, 0, 1, 0, 1, 5), (1, 0, 0, 1, 1, 10), (0, 1, 1, 0, 1, 5), (0, 1, 0, 1, 1, 10), (0, 0, 1, 1, 1, 10)}.

The sub-part "B.2" presents the link between states. If the elapsed time in next states in any step in the game is over than 17 or equal to 17 and one or more of the rest variables equal to 0, the game displays a failure icon next the state like in "B.3". If the learner does not solve the problem, the game can give you the hand to try again the game and conserve in the part B all the state visited by him/her.

The harmony between the two parts A and B helps the learners to learn how to represent AI problems with state-space approach in an amazing game environment.

4 Conclusions

We have described a bridge crossing game for assisting learners to learn artificial intelligence problem solving. Common difficulties experienced by learners in studying problem solving were identified and the BCG was designed to assist with these difficulties. The BCG operates in 3D environment. 3D environment facilitate the learning of the individual steps of a problem solving representation while BCG facilitates learning of the representation of problem solving by state-space approach.

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Evaluation of online assignments and quizzes using Bayesian Networks

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Abstract. This work presents a novel approach to evaluate the relevance of online quizzes and assignments on the success of students in an online exam, using Bayesian Networks BNs. The case under consideration is the module Preparation to Computer Science and Internet Certificate PC2i, learned in licenses' first year, using the online platform Moodle, in Tunisia [6]. The main problem to be faced is what pedagogical activities are to be used in order to prepare students to succeed their C2i certification exam. BNs are used to automatically model relations between licenses' names, assignments, quizzes and results of students in an online exam.

Keywords: e-learning, Bayesian Networks, evaluation of quizzes, evaluation of assignments.

1 Introduction

With e-learning, the learner must be in the core of the learning process; trained according to his needs using interesting, suitable and value-added content in the most efficient way. Design, conception and evaluation of the impact of online resources and activities on the learning process are very important. Always online activities are presented to learners without assessing their impact and interest in relation to concepts having to be mastered. It is therefore difficult to determine relevant activities. This work presents a novel approach to evaluate online activities, such as quizzes and assignments, in the module Preparation to Computer Science and Internet Certificate PC2i, using Bayesian Networks BNs. Data used for an automatic learning of BNs is obtained from reports generated by Moodle platform. The result is an automatic construction of BNs representing relations between license's name, assignments, quizzes and student performance in an online supervised exam. Using inference, relevant assignments and quizzes are determined.

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2 PC2i in Tunisia

Computer Science and Internet Certificate C2i is a certificate attesting development, enhancement, validation and mastering of Information and Communication Technologies ICT. The module Preparation to C2i, PC2i is mandatory and taught in the license's first year, using Moodle platform [6]. PC2i enables preparation of students to obtain the certificate C2i level one, which is managed by the Virtual University of Tunis VUT [3]. The C2i certification exam contains 2 parts. In the theoretical part, multiple choice questions are presented. The practical part deals with mastering Web research, word processing, spreadsheets and presentations. Success of students in this exam may be based on the quality of online quizzes and assignments developed by the C2i team. We have already developed an intelligent tool to accomplish a classification of students, to facilitate their selection for the certification exam [3].

3 Bayesian Networks

3.1 Presentation

e-learning problems and processes can be represented using uncertain and causal relations [4]. For this reason, our approach is based on the use of Bayesian Networks BNs [7]. These Directed Acyclic Graphs DAGs are largely accepted to be interesting tools to model uncertain reasoning and enable a faithful representation of causal relations among a set of random variables [7]. A set of mutually exclusive states and a Conditional Probability Distribution CPD are related to each variable X_i. In a BN, each node is independent from the others, giving its parents. The joint probability distribution JPD is represented by the following formula:

$$p(X_1,..,X_n) = \prod_{i=1}^{n} p(X_i | parents(X_i)) \tag{1}$$

When evidences are available, probabilities related to different nodes can be calculated using inference algorithms based on the Bayes rule.

3.2 Construction of a BN

In this work, the construction of the BN is based on the use of data structured in a database. We have used Bayesian Network tools in Java BNJ [1] to automatically construct the BN. The K2 algorithm [2] is used, where the expert defines an order or a hierarchy among variables. Previous variables, to a defined variable are tested if they can be its parents. Multiple orderings are given by the domain expert in order to reduce K2's sensitivity to nodes ordering. The fully connected and most suitable BN is then adopted.

4 The automatic evaluation of online assignments and quizzes approach

Data recuperated from Moodle platform, is represented by 714 records, for the academic year 2008-2009. Students are from the Higher Institute of Computer Science and Management- University of Kairouan HICSM-UK.

4.1 Data recuperation

The data used concerns identification of students, their marks in quizzes, assignments and online exam. The Grader Report presented in the Administration block in Moodle is used. It contains students ID, first Name, last name, email and obtained marks in quizzes, assignments and exam. Data is exported using Excel spreadsheets. The Participant block in Moodle is used to recuperate the list of participants classified by licenses' groups. Data are stored into two spreadsheets. In the file students.xls, we have student' ID, first and last names, license's name and marks in the exam. In the file activities.xls, we have the identification of students and their marks in quizzes and assignments.

4.2 Data storage

Data is gathered and stored in a database using a recuperation process from XLS files. Only one table is used. Its attributes are students' ID, first and last names, licenses' names, marks in quizzes, assignments and online exam.

Treatment of missing data. Missing values may be observed in data gathered. It concerns marks affected to assignments, when they are not corrected by tutors. The nominal value (most frequent one) or the average value may replace numerical missed values. The average mark in the license is chosen to replace missing values.

This choice is motivated by the fact that students affected to different licenses have different profiles.

Discretization process of data. The discretization process is the process of portioning continuous data into different classes. The number of intervals and their boundaries are to be determined. Discretization is the fact of finding a compromise between consistency, simplicity and classification accuracy [6], [7]. Three classes are adopted, represented by these intervals: low ([0..10[), medium ([10..14[) and good ([14..20]).

Retained criteria for evaluation: Nodes of the BN. Retained criteria are license name, quizzes, assignments and online supervised exams.

4.3 Automatic construction of the BN

Automatic learning of a BN’s structure and parameters from a database is the automatic construction of BNs. We have chosen to use the K2 algorithm [2]. This greedy search and score-based algorithm, is developed by Cooper and Herskovits [2]. It is based on the maximization of the structure’s probability given data. The domain expert has to specify variables' order. Used in multiple real problems, K2 is able to construct in a rapid manner BNs with a moderate complexity[2].

5 Developed Web application using BNJ classes: Automatic Evaluation of PC2i assignments and quizzes

Bayesian Network tools in Java BNJ [1] are used in our work. We have developed a C2i Automatic Evaluation System C2iAES for an automatic evaluation of assignments and quizzes. It is a PHP5 Web application. Evidence about the online exam is introduced to evaluate the impact on quizzes and assignments. Data is sent from the web interface to the developed inference class in Java using an XML file, Observed.xml. This file is parsed using the Application Programming Interface API Java Document Object Model JDOM. Java classes are developed to handle data, create the BN and to recuperate the result of the evaluation process.

6 Use of the developed Web application C2iAES

Three main menus are presented in the developed Web application C2iAES. The first one deals with the creation of a project and the database. The second one, presents evaluation using an inference process. The third one enables loading of an existing project.

At first, the user specifies the name of the project. A folder is then created to store used and generated files. The user introduces data using two XLS files: students and activities. In the next step, a database having the same name as the project, is

then automatically created and filled with data retrieved from XLS files. An automatic treatment of data is also accomplished, for instance to replace missing values or to eliminate students having no assignments and no quizzes.
Using the second menu named Activities evaluation; BNs for evaluation are constructed automatically using the K2 algorithm and different ordering versions specified by a domain expert. BNs are presented to the user in order to select the most suitable one. The BN chosen, which best explains causal relations between variables, must be a completely connected one, while being a convincing model to the evaluation problem.
The evaluation of activities is then accomplished by the introduction of data in the BN as evidence gathered. A web interface is used for this issue. The final result is an XML file presenting evaluation results.
An existing project can be easily loaded using the third menu. The user is able to choose the BN and to accomplish a new evaluation of activities, after the introduction of new evidence.

Test results. The BN chosen is presented in Fig. 1. Quizzes are represented by nodes T1,..,T6. Assignments are represented by nodes D1,..,D10. The online exam is represented by the node DS1.

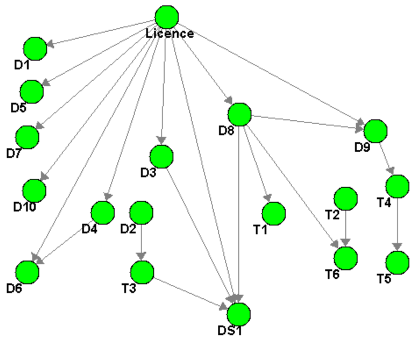

Fig. 1. BN's Structure

The user introduces evidence to the BN using a Web interface to indicate that results in the exam are good, for instance. The result of the evaluation is presented in Fig. 2. It is the XML file, Observed.xml. To obtain a good result in the online exam, the most interesting quizzes are T1, T2 and T6. Interesting assignments are D1, D2, D3, D4, D5, D6 and D8. The impact of the license is also important specially related to computer science SI.

Activities Evaluation

NODE	STATES AND PROBABILITIES
D1	1. P(medium) = 0.0 2. P(Good) = 1.0 3. P(Low) = 0.0
D10	1. P(medium) = 1.0 2. P(Good) = 0.0 3. P(Low) = 0.0
D2	1. P(medium) = 0.0265017667844523 2. P(Good) = 0.9381625441696113 3. P(Low) = 0.03533568904593639

Fig. 2. Evaluation Results

7 Conclusion

The impact of online assignments and quizzes on the success of learners should be well studied and evaluated. In this paper, we present our proposed evaluation methodology of quizzes and assignments. BNs are used to obtain a reliable model of the relation between licenses' name, assignments, quizzes and results in an online exam. The evaluation approach is important for the construction of a good- quality online course. Students will be concentrated on interesting activities. Similar data in any module can be used and our approach can be easily applied. As perspectives, we propose the evaluation of the content of other types of courses and activities, such as the use of workshop activities and peer assessments in XML and Web development courses. We propose also the integration of this application under Moodle platform.

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Mindcraft : A novel mind mapping tool under Moodle platform

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Abstract. In this work, we present a novel developed plugin, Mindcraft integrated to the Moodle platform. It gives the opportunity to teachers to create mind maps. It is an interactive and collaborative tool used to structure information by connecting ideas and concepts using personalized and rich mind maps.

Keywords: Mind mapping, Moodle, Mindcraft

1 Introduction

e-learning is getting to be developed in Tunisia thanks to the Virtual University of Tunis VUT. The e-learning Moodle (Modular Object Oriented Dynamic Learning Environment) [4] platform is installed and managed by the VUT. Moodle is an educational platform designed to create customized, interactive and collaborative e-learning environments. The aim of this work is to integrate to moodle, a collaborative and interactive online activity for mind mapping. In this context, we have developed in June 2015, a new mind mapping plugin. This tool can be used in several domains such as training sessions at the VUT, in medicine, entrepreneurship, etc. This work is the result of the collaboration between the department of virtual education at the University of Manouba and the VUT.

2 Mind Mapping approach

Mind mapping is an interesting approach for brainstorming and idea generation, used to facilitate structuring of items, concepts, ideas, etc. of a given problem [2]. It consists in presenting a central idea, connected to it other ideas in a hierarchical manner. For instance, organization of concepts in a course, a case study in medicine, a project in entrepreneurship, etc. It also stimulates creation, reflection

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and innovation, while saving time [2]. It avoids falling into a chaos by managing a large amount of information without losing important details. Online interactive and collaborative mind mapping tools can be used to structure concepts and ideas between multiple users. Sharing ideas, discussion, logical thinking and synthesis become easier.

3 Mind mapping under Moodle

The online learning platform Moodle does not provide a mind mapping tool, able to satisfy basic requirements of communication and collaboration between teachers and students about concepts, ideas, projects, etc. represented by a mind map.

To create mind maps, the Moodle plugin named "Advance mind map" [1] can be used. There is no collaborative aspect in its version number 2014080500. Therefore, this plugin is not very useful and doesn't satisfy users' needs. It doesn't offer any interactive aspects and relations between nodes are limited to only one level. Also, there is no way to customize nodes such as by using different colors, shapes, or by attaching media files, etc.

Teachers can also use an external tool to moodle that offers all needed features. For Moodle users, this kind of solution is not very interesting nor effective, and would make the learning/training process not very convenient.

Due to the lack of an interactive and collaborative mind mapping tools under Moodle, we propose to develop a new mind mapping plugin to be integrated to Moodle platform.

4 Developed plugin: Mindcraft

The process of developing and integrating the new plugin Mindcraft into Moodle, follows multiple steps. Different Web developing languages and technologies are used. From the client side, used technologies and languages are HTML5, CSS3 and JavaScript JS. As JS libraries, jQuery and GoJS [3] were used. GoJS was used as a main tool to manage maps (adding nodes, relationships, etc.). Ajax was used to manage submission of comments and saving maps. From the server side, the plugin was developed in PHP5 using the library offered by Moodle for plugin development. For data modeling, JSON was used for modeling maps and XML for modeling tables used by this plugin. A responsive web design was developed for this plugin to be adaptive for small screens and Moodle mobile application.

5 Presentation of Mindcraft

When working in a group, interactive and collaborative aspects are important. The main aim of this work is to develop a plugin to be integrated to Moodle offering the same features as any powerful mind mapping tool external to Moodle. The mind mapping developed tool is named Mindcraft. This tool is useful for making analyzes, summaries, taking notes and facilitating memorization of concepts under Moodle.

This application looks to structure information by connecting ideas with logical links and associations between them. It allows to focus on details while keeping a global vision of the problem under consideration. It helps to clarify ideas by presenting them with images, links, media files, colors and shapes.

The user has the ability to customize maps, in collaboration with other users. The visual rendering may be more attractive, more representative, easy to understand, more accepted into a group and then easily transmitted, since it represents the result of collaborative work obtained with consensus. Mindcraft, the new Moodle plugin offers different features for students and teachers.

Main features offered by Mindcraft for teachers are creation, updating and deletion of mind maps, nodes and links. The teacher starts by adding a new Mindcraft activity under Moodle. The name of the mind map, its description, the number of maps and if maps will be interactive, are specified in the creation interface.

The list of available and created mind maps is then shown to the teacher, with different information about state, creation and last updated dates. When clicking on a map, the teacher has the possibility to add nodes to the new created mind map. The main problem node is displayed automatically as presented in figure Fig.1. The mind map can be then, renamed, validated or deleted.

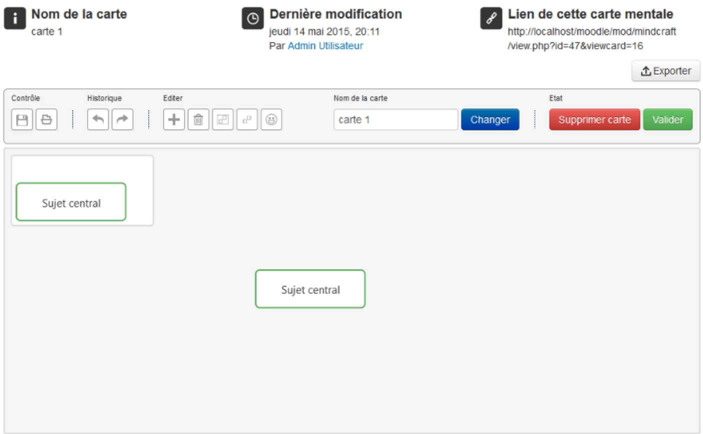

Fig. 1. Interface for managing a mind map

Each node in a mind map can be customized using different descriptions and shapes. Colors of texts, borders and backgrounds can be modified. To each node,

pictures, hypertext links and files can be attached. Relations or links between nodes are allowed at different levels with different shapes and colors. Discussions about nodes can be accomplished between users using a comment system.
Collaboration between teachers is also implemented by tracking changes on nodes and managing different versions. Added files can be downloaded and hypertext links can be visited by collaborators. If the map is validated by the teacher, it can be then, displayed to students and exported as a picture.
Main features offered by Mindcraft to students are consultation of created and validated mind maps, which can be downloaded as a picture. Hypertext links can be visited and files can be downloaded from each node. Discussion by a comment system can be started on each node between teachers and students.

6 Conclusion

Mind mapping is an interesting approach for extracting, storing, structuring and sharing information [2]. It is very useful in education to summarize important concepts and explain links between them. Online mind mapping tools are then needed, to take advantage of different benefits of mind mapping.
This work proposes a novel plugin for a collaborative and interactive mind mapping tool under Moodle platform. This approach represents several features for teachers and students. Mindcraft was developed under the version 2.8 of Moodle and it is still compatible with the versions 2.9 and 3.0. Mindcraft 1.0 is still under the approval process from the Moodle community. We are already working on a new version, Mindcraft 2.0, presenting important additional features, such as the possibility to choose the map's type (mind map, flowchart, Gantt, UML diagram, etc.). Users (teachers and students) will be able to collaborate into groups to create a new map. Assessment of students will be done also under Moodle. This new plugin can be used to boost creativity of learners and collaboration between them.

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Assessing Learners' Progress in a Smart Learning Environment using Bio-Inspired Clustering Mechanism

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Abstract. Learning Analytics systems can analyze and measure learners' data to infer competence, meta-competence, and confidence measures. While catering to the needs of students, the Learning Analytics system also measures effectiveness and efficiency of the learning environment. These measures enable the Learning Analytics system to auto-configure and auto-customise itself to offer personalized instruction and optimal learning pathways to students. Such a Learning Analytics system can be classified a Smart Learning Environment, where learner engagement initiatives are auto-generated by the system itself. This paper proposes the Parallel Particle Swarm Optimization (PPSO) clustering as a mechanism to trigger learning engagement initiatives. Using PPSO, learners are clustered using similarity measures inferred from observed competence, meta-competence, and confidence values, in addition to effectiveness measures of instructional tools. A simulation study shows that the PPSO-based clustering is more optimal than Parallel K-means clustering.

Keywords: Smart learning environment, Learning Analytics, Clustering, Competence, Meta-Competence, Confidence.

1 Introduction

Learning analytics is about insights. Insights could be detected, analysed, or created in the context of variables such as the quality of interactions with the content, study habits, engagement, competence growth, sentiments, learning efficiency, and instructional effectiveness [1]. Smart Competence LEarning Analytics Platform (SCALE) [2] is our in-house learning analytics engine designed and developed to track the finer-level learning experiences and to translate those experiences into measurements of competence, confidence, feedback, reflection, and regulation. SCALE handles the continuous arrival of observations of an exhibition of specific skills - e.g., a student has consistently exhibited the skill of writing if-else control structure within a while loop without errors. Each observation that triggers changes in competence levels of specific skills is also tagged with the learning context of the observation. The context includes knowledge level of the student in the target concepts, effort of the student in and around the target concepts, and the effectiveness of learning resources utilized by the student related to the concepts. It calculates the 'change' in the skill

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value of the student with respect to if-else and while constructs and propagates these updates upwards to higher order proficiencies such as control structures. This 'change' is skill levels and the corresponding 'context' determine if the observation (observation = [change, context]) approaches a particular 'learning outcome'. A learning outcome is defined using the new Bloom's taxonomy (e.g., apply if-else). Proficiency is measured in the range of [0 - 1]. The proficiency of a skill could approach the target threshold of a learning outcome. For instance, the current proficiency is at 0.30 in "if-else+while", and the new proficiency is computed as 0.35. The context indicates that the student 'generated' a new piece of code corresponding to an assignment problem. The context also indicates the time (e.g., total time taken so far for a given set of concepts) and effort (e.g., grit) of the student. Given these pieces of information, SCALE calculates the degree to which the learning outcome "apply if-else+while" has been achieved. That is, currently, SCALE computes 'proficiency' but with the inclusion of the context of learning, SCALE computes 'competence', the degree to which a learning outcome has been achieved, given the context. This degree of achievement, what we call competence of 'apply if-else+while', can also be in the range of [0 - 1]. These competence changes can be observed throughout the study period, across various learning episodes, for each learning outcome defined in a course.

The volume, arrival rate, and processing complexity of data arriving from learners' study episodes, in a rather continuous manner, leads such analyses closer to big data learning analytics. An earlier research [3 & 4] had that studied the clustering of the continuous arrival of learners' data was based on competence measures such as efficiency, quality, and accuracy. However, Brown & McCartney [5] state that learners' competency measures are not enough to understand the higher-order ability of the learners. They indicate that measurement of meta-competence is essential to infer judgment, intuition, and acumen upon which competencies are based. The current system measures meta-competence such as self-regulation and grit, and a measure of confidence, in addition to domain-specific competences. This paper presents a bio-inspired Parallel Particle Swarm Optimization (PPSO) clustering mechanism that clusters students based on a competence factor, a generic meta-competence factor, and a confidence factor. Such a clustering allows one to assess the progress of students, for instance, in a semester long course.

The main contributions of this research paper are:

- The design of a system to collect competence, meta-competence, and confidence measures.
- The design of a PPSO clustering mechanism to cluster students as and when new data competence, meta-competence, and confidence arrives.
- A simulation study to analyse the performance of the PPSO against other clustering mechanisms in terms of cluster-to-cluster distance, cluster-member distance, and member-member distance.

The rest of this paper is organized as follows: Section II describes related literature. Section III discusses the proposed algorithm. Section IV describes the system architecture of the SCALE system with PPSO. Section V discusses the experimental setup and the results. Section VI concludes the paper with recommendations and future work.

2 Related Works

Govindarajan et al. [3 & 4] proposed a system to handle the continuous arrival of student's data and cluster learners based on competence measures in a learning analytics platform. Aljarah and Ludwig [6] developed a parallel PSO clustering algorithm using the MapReduce technology, which is iterative in nature that takes a large amount of time to complete the clustering process. Li et al. [7] proposed a MapReduce-based k-means clustering algorithm, which uses the ensemble learning method for solving the outlier problem. Geyik [8] proposed the clustering of learners based on attributes such as recently accessed materials, frequently accessed materials, and monetary factors, where a hierarchical clustering algorithm clustered learners based on the self-organizing map, followed by a non-hierarchical fuzzy clustering. Valsamidis [9] discussed the Markov clustering of learners based on their activities with respect to enrichment, interest, and disappointment. McNabb et al. [10] introduced a MapReduce-based parallel Particle Swarm Optimization. Cui et al. [11] proposed Particle Swarm Optimization based clustering of documents using cosine similarity as a measure. Dheeban et al. [12] proposed a PSO algorithm, where learners are grouped based on their ability level and perceived difficulty of the course, thus allowing an estimation of a course's suitability for a learner. Weizhong et al. [13] proposed a k-means parallel clustering algorithm based on MapReduce. This algorithm selects the initial centroid value in a random manner. The Map function calculates the weighted average values of the points within a cluster to determine the scope of the cluster. Cui [14] proposed a parallel PSO in Spark platform for solving the big data energy optimization problems, which is estimated to be 32 times faster than the Map Reduce based approach.

The main difference between contemporary PPSO and the work described in this paper is the clustering of learners based on the competence, meta-competence, and confidence measures by applying a bio-inspired Parallel Particle Swarm Optimization (PPSO) algorithm to assess the learners' progress in a programming language course. Conventional clustering mechanisms fails to handle the continuous arrival of data from a learning analytics environment, since they would require a restart as and when new data arrives. K-means and parallel k-means algorithms lead to poor clustering due to the random selection of centroids. The approach to clustering of learners described here stems from the need to associate learners' membership in multiple clusters to measure the growth of their competence, to measure the progression of their confidence, and to measure the growth of their meta-competence. In general, traditional clustering techniques that handle numerical or categorical data are not readily applicable for the clustering of continuous data from learning analytics systems.

3 Bio-inspired PPSO Clustering Algorithm

The bio-inspired PPSO has been applied in the domain of students learning to program in a computer language. It results in an assessment that not only identifies the strengths and weakness of a learner but also provides feedback to learners and teachers a comparative analysis of growth of competences among learners. Learners could be clustered based on domain-specific competences or meta-competences or confidence measures. Each learner could belong to a number of clusters and new clusters emerge as data arrives continuously. One could also analyze the distance between clusters as a means to guide learners towards better performance.

The Parallel Particle Swarm Optimization (PPSO) algorithm described in this paper is a population-based artificial intelligence mechanism, which is inspired by social behavior of a swarm of birds. PSO is a bio-inspired optimization technique that has been adapted to handle the continuous arrival of learners' data from the learning analytics platform. It is an iterative algorithm. It employs swarms of particles, where every particle is responsible for tracking the fitness of each other particle. Every particle is associated with a corresponding velocity that helps the particle to move to the best position and every particle in the swarm searching the multidimensional solution space to search for a better solution. Each swarm entity is called a particle, and every particle is responsible for tracking its own fitness using a fitness function that evaluates the performance of the particle in each iteration. Every particle is associated with the corresponding velocity that helps the particle to move to the best position. The convergence of PSO depends on the particle's personal position and the global best position of the swarm.

The first step is to initialize the dataset with local best position, local best value, global best position, and global best value. The initialization process takes two inputs, the number of processors and the swarm particles, and returns the output as sub-swarms for each processor. Each particle in a swarm has K dimensions that represent a cluster centroid. A particle P_i is represented as $(C_1, C_2, ... C_k)$ and each dimension C_g is represented as $(Competence_{S_i}, Metacompetence_{S_i}, Confidence_{S_i})$. Every node receives a sub-swarm of particles represented as $Particle_{p_i}$ and each node P_i initializes its particles personal best value, global best value, personal best position, and global best position. The fitness value is calculated using the fitness function (1) after assigning the initial values.

$$F\left(Pa_i \in Particle_{p_i}\right) \leftarrow \frac{\sum_{C=1}^{K} \sum_{A=1}^{N_{CC}} d\left(C_C, (S_a)_C\right)}{K} \qquad (1)$$

After computing the fitness value for each particle, the particles' personal best value and personal best position are computed. Then, the global best value and global best position for each sub-swarm are computed. Once the global best value and global best position are found, the minimum global best value among all the processors is computed and this value and its position are communicated to other processors.

4 System Architecture

The system architecture of an analytics system that uses the bio-inspired PPSO is shown in Fig.1. The data aggregator collects learners' data from three tools used by students – the Moodle LMS, the MI-Writer writing analytics system, and the NetBeans IDE. It sends those collected data to the data storage manager and data preprocessor to store the data in the MySQL database virtual instance and preprocess the learners' data.

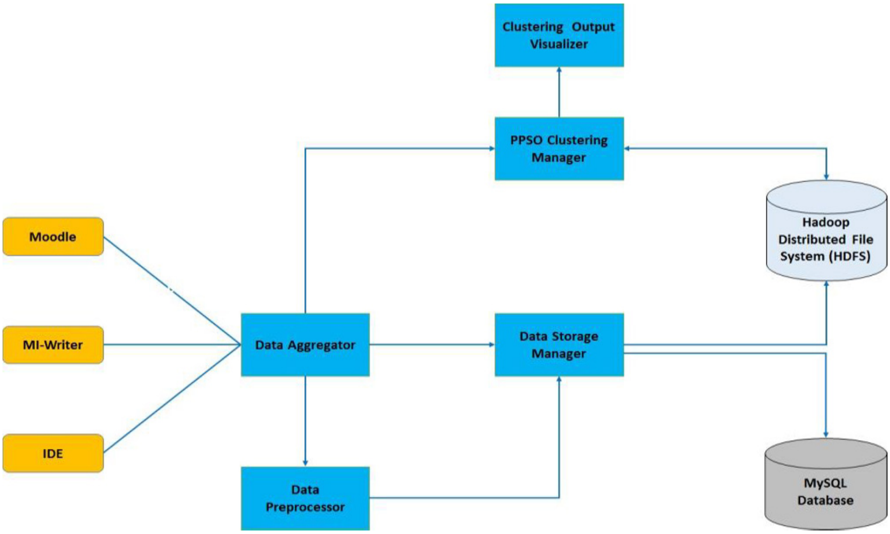


Fig.1: System Architecture

The data preprocessor filters data by removing unwanted fields such as the name and other such identifiers. The preprocessed data is stored in the Hadoop Distributed File System (HDFS). The preprocessed data is converted into competence, meta-competence, and confidence values. The PPSO clustering manager embeds the PPSO algorithm, which utilizes the preprocessed learners' data and clusters learners based on their competence, meta-competence, and confidence. Finally, the analyzed learners' data is fed into the clustering data visualizer to visualize the performance measures such as cluster to cluster distance, cluster to member distance, and member to member distance. The input and output data view representation is shown in Fig.2.

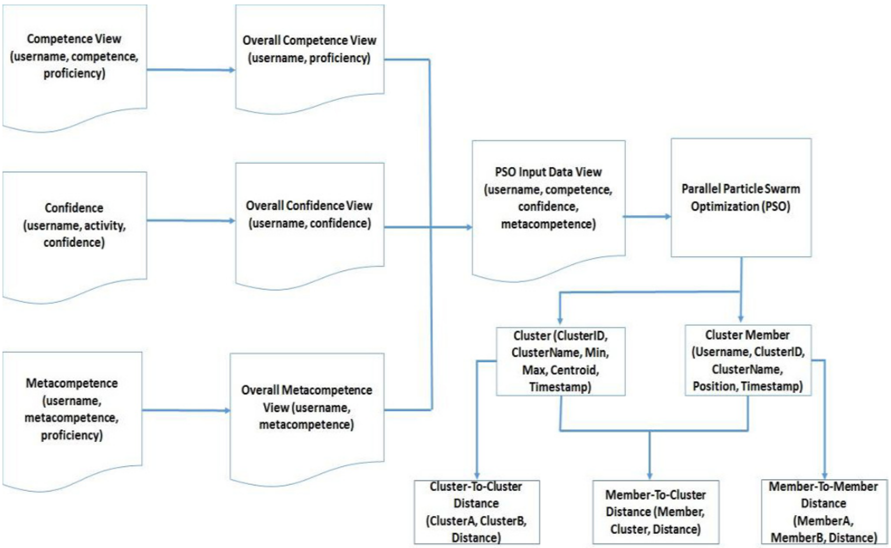


Fig.2: Input and Output Data View

5 Performance Measures & Experimental Results

The performance of the PPSO approach is measured by the following three parameters: (i) Cluster-To-Cluster Distance (ii) Member-To-Cluster Distance, and (iii) Member-To-Member Distance.

***(i) Cluster-To-Cluster (C2C) Distance* –** It represents the dissimilarity between the clusters. It is calculated based on the difference between the cluster centroids. Higher C2C values represent a higher degree of cluster classification. Figure 3 represents how the C2C values were calculated in the PPSO.

(ii) Cluster-To-Member (C2M) Distance – It represents the sum of distances between all the members belonging to the cluster which represents the compactness of the cluster. Smaller C2M values indicate higher degree of compactness of clusters. Figure 4 represents a pictorial representation of Cluster-To-Member (C2M) distance calculation between the cluster centroid and the members in each cluster.

(iii) Member-To-Member(M2M) Distance – It represents the dissimilarity between the members in a cluster and across the clusters. Figure 5 represents the pictorial representation of Member-To-Member(M2M) distance calculation.

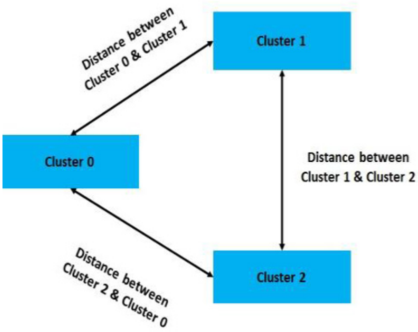


Fig.3: Cluster-To-Cluster (C2C) Distance

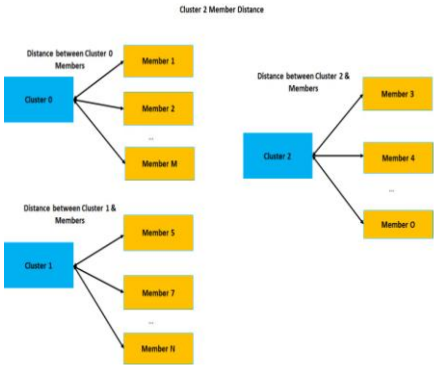


Fig.4: Cluster-To-Member (C2M) Distance

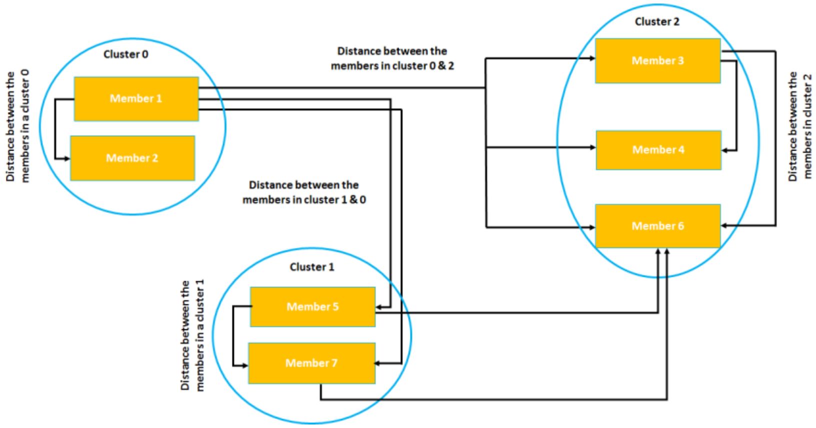


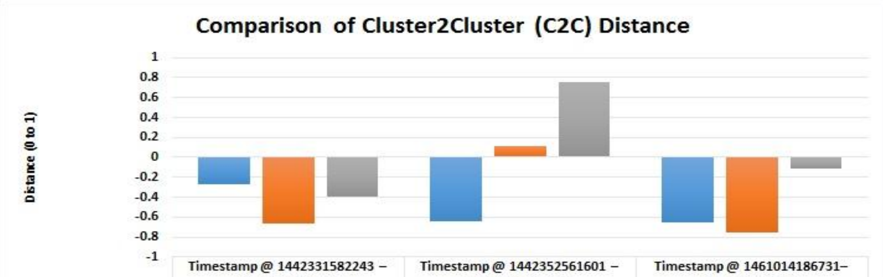
Fig.5: Member-To-Member (M2M) Distance

Experimental Setup - This section discusses the experimentation parameters designed to test Parallel Particle Swarm Optimization (PPSO) mechanism integrated with SCALE platform in an Apache Spark cluster environment. The parameters used for the simulation experimentation are shown in Table 1.

Table 1: Simulation Parameters

Parameters/Algorithms	**PPSO**	**Parallel K-Means**
Number of Learners	100 – 2000	100 – 2000
Number of Problems Per Learner	100 – 200	100 - 200
Number of Particles	100	100
Number of Clusters	3	3
Type of Clusters	{Good, Bad, Average}	{Good, Bad, Average}
Termination Criteria	100	100

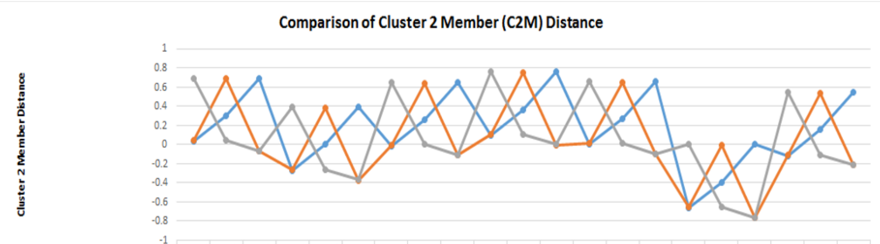
Real data about learners' coding experiences were collected and estimates on competence, meta-competence, and confidence parameters are computed. The simulation experiment was carried out for 100 – 2000 learners and the proposed system is accessed by 'N' number of learners arriving at a regular interval of λ based on the Poisson distribution. The simulation experiment was conducted for a total of 100 – 200 problems for each learner. Learner study experiences are randomly generated corresponding to estimates of competence, meta-competence, and confidence based on the observed Poisson distribution of real-time data. The cluster 2 cluster (C2C) distance was calculated in three different time intervals and the calculated values are shown in Fig 6. The minimum value represents the density of the cluster calculated in three different timestamp intervals.



	Timestamp @ 1442331582243 – Cluster Distance	Timestamp @ 1442352561601 – Cluster Distance	Timestamp @ 1461014186731– Cluster Distance
Cluster 1 - Cluster 0	-0.269939636	-0.644695841	-0.650652185
Cluster 2 - Cluster 0	-0.662394328	0.111085887	-0.760033618
Cluster 2 - Cluster 1	-0.392454692	0.755781728	-0.109381433

Fig 6: Comparison of C2C Distance

The cluster 2 member (C2M) distance was calculated for three different timestamp values. The distance between the member centroid value and the associated cluster centroid value is minimum, however the distance between the cluster member and the other cluster centroid value is maximum as shown in Fig.7.



	user12 - Cluster 0	user12 - Cluster 1	user12 - Cluster 2	user2 - Cluster 0	user2 - Cluster 1	user2 - Cluster 2	user 30 - Cluster 0	user 30 - Cluster 1	user 30 - Cluster 2	user4 - Cluster 0	user4 - Cluster 1	user4 - Cluster 2
Distance at @ 1442331582243	0.03403	0.30397	0.69642	-0.2699	-4E-08	0.39245	-0.0117	0.2582	0.65065	0.09764	0.36758	0.76003
Distance at @ 1442352561601	0.04482	0.68951	-0.0663	-0.2591	0.38555	-0.3702	-0.001	0.64375	-0.112	0.10843	0.75313	-0.0027
Distance at @ 1461014186731	0.69642	0.04577	-0.0636	0.39245	-0.2582	-0.3676	0.65065	0	-0.1094	0.76003	0.10938	0

	user 500 - Cluster 0	user 500 - Cluster 1	user 500 - Cluster 2	user 600 - Cluster 0	user 600 - Cluster 1	user 600 - Cluster 2	user 1000 - Cluster 0	user 1000 - Cluster 1	user 1000 - Cluster 2
Distance at @ 1442331582243	0.00016	0.2701	0.66255	-0.6624	-0.3925	-4E-08	-0.115	0.15493	0.54738
Distance at @ 1442352561601	0.01095	0.65565	-0.1001	-0.6516	-0.0069	-0.7627	-0.1042	0.54047	-0.2153
Distance at @ 1461014186731	0.66255	0.0119	-0.0975	0	-0.6507	-0.76	0.54738	-0.1033	-0.2127

Fig 7: Comparison of C2M Distance

The proficiency values of the learners are computed for the learners in three different time intervals. By providing the recommendation to the learners, the learners are moving from one cluster to another cluster (for ex: Bad –> Average, Average -> Good) in a period of time. The proficiency level of the learners are calculated in three different time intervals as shown in Fig.8.

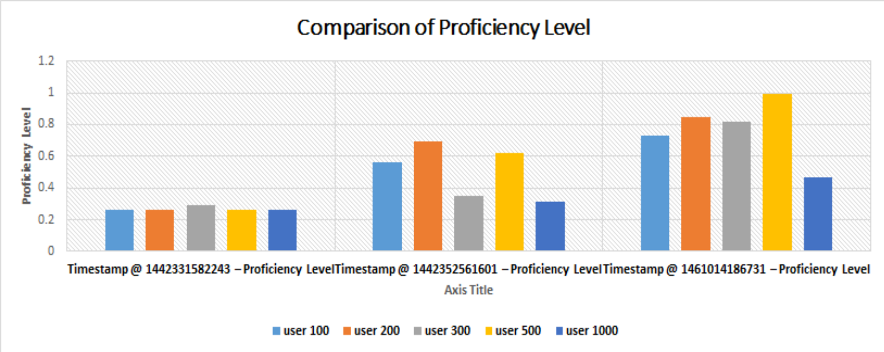


Fig. 8: Comparison of Proficiency Level

To evaluate the accuracy of the proposed clustering approach, IntraCluster Distance (IntraCD) and InterCluster Distance (ICD) are calculated. The calculated values are compared with outcomes from a Parallel K-Means algorithm. The comparison of IntraCD and ICD are shown in Fig. 9 & Fig.10. The minimum value of IntraCD represents the compactness of the cluster and the maximum value of InterCD represents the accuracy of the cluster members' in each cluster.

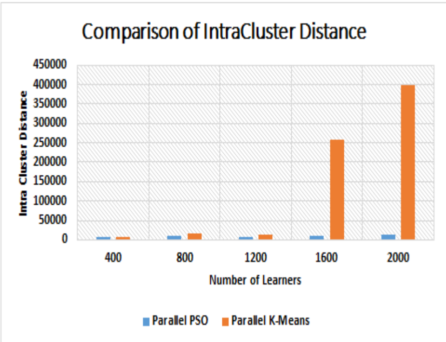


Fig 9: Comparison of IntraCluster Distance

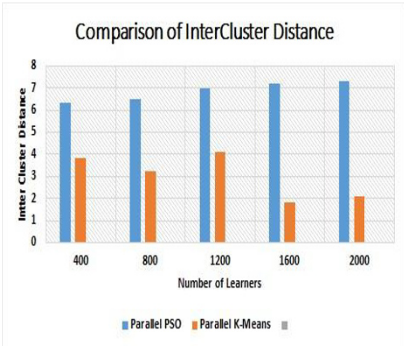


Fig 10: Comparison of InterCluster Distance

6 Conclusion and Future Work

SCALE is a learning analytics platform that analyzes learners' competence, meta-competence, and confidence measures in a Smart Learning Environment (SLE). The system provides an on-demand and adaptive support for the learners based on their needs. The use of a PPSO in the context of a learning analytics is presented and the performance of the PPSO is discussed. The future work aims to develop a clustering-based prediction to predict potential cluster memberships for learners.

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Toward the selection of the appropriate e-learning personalization strategy

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Abstract. Many recent studies have proposed several e-learning personalization systems that could be used in the learning field. In particular, the divergence of the personalization parameters used in the literature makes the selection of the appropriate personalization strategy to apply for a given course complicated. Therefore, this paper presents a web-based system which aims to help teachers select the appropriate combination of personalization parameters for a personalization strategy for a given course. The selection process made by the system is based on Dynamic Programming. Thirty one student-teachers participated in evaluating the system using Technology Acceptance Model (TAM) questionnaire. The obtained results were very promising where the student-teachers revealed a high perceived ease of use and usefulness toward the system. Besides, they reported that they are willing to use the system in the future to select the appropriate personalization strategy of a given course.

Keywords. e-learning, adaptive learning, dynamic programming, Personalization.

1 Introduction

Traditional learning has usually followed one size fits all approach without taking into consideration the differences between learners [1]. This can affect negatively the learning process and its results. With the Advances of Technology Enhanced learning (TEL), researchers have thought of using personalized learning systems where the learners' individual needs are considered [2]. According to the National Academy of Engineering [1], advance personalized learning is one of the 14 most important challenges of the 21st Century.

However, many personalization parameters are proposed in the literature which can be used during learning personalization. For instance, Essalmi et al. identified

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19 personalization parameters in [3, 4]. These parameters include fifty nine learner characteristics. Thus, each concept of a course should be represented in fifty nine ways (learning objects) in order to satisfy all learner characteristics. This is time consuming and not motivating, since learners have to answer different questionnaires related to each personalization parameter which are long. For example, to know the personality of a learner, he/she has to answer the Big Five Inventory (BFI) questionnaire [5] which contains forty four questions. Besides, teachers have to spend a lot of time creating the required fifty nine Learning Objects (LO) which is very hard and complicated. Therefore, the main research question that this paper aims to answer is *How to select the appropriate e-learning personalization strategy for a specific course?*

In this context, this paper presents a new approach for the analysis and selection of the appropriate personalization strategy. It is based on the Dynamic Programming method which is widely used in the operations research field to find the optimal solution of a given problem. The proposed approach takes into consideration two criteria which are as follows:

- Maximize the availability of LOs, based on the learner characteristics for a particular personalization parameter, of a given course.
- Minimize the time spent by learners answering questionnaires related to a particular personalization parameter.

The rest of the paper explores the proposed research question as follows: section 2 presents a literature review regarding personalized learning systems and the available metrics for the analysis of the personalization strategies. Section 3 presents the proposed approach and the implemented system used to select the appropriate personalization strategy. Section 4 presents the conducted experiment to validate the proposed system. Finally, section 5 concludes the paper with a summary of the findings, the limits and potential research directions.

2 Literature Review

Applying one size fits all strategy in learning can affect negatively learners' learning motivation and performance. Therefore, learning experiences should be personalized according to each learner's profile. This profile contains the characteristics of a learner. This section presents examples of developed personalized systems in the literature. Besides, it investigates the proposed approaches or methods to select the appropriate personalization strategies.

2.1 Personalized Learning Systems

Personalized learning systems aim to identify the learners' needs and apply the learning strategies that best fits them. Uniform learning approaches can make learners perform poorer academically [6]. Various personalized systems are developed based on different personalization parameters. For example, ML-Tutor [7] is an adaptive web-based information system which uses learning goals as a personalization parameter. Interbook [8] uses the learner's level of knowledge to serve a personalized learning experience. There are also several e-learning personalization systems which use a combination of personalization parameters. For instance, EDUCE [9] allows the personalization of the course according to the learning goals and Gardner's multiple intelligences [10]. In DCG [11], the personalization of learning is based on the learner's level of knowledge and learning goals. AST [12] is a system which is based on a conceptual model of the domain of introductory statistics adapted to the learner's level of knowledge, media preferences and learning goals. Other studies have attempted to integrate learning styles as a personalization parameter of learning scenarios. In this context, Oscar CITS [13] is an adaptive educational system which provides learners with personalized course according to the Felder–Silverman learning style and the learner's level of knowledge.

Table 1 summarizes this section by presenting the six personalized learning systems described above. In particular, the second column presents the personalization parameters that each system used.

Table 1. Examples of personalized learning systems.

Personalized e-learning systems	Personalization parameters
MLTutor [7]	Learning goals
Interbook [8]	Learner's Level of knowledge
EDUCE [9]	Learning goals, Gardner's multiple intelligences
DCG [11]	Learner's level of knowledge, learning goals
AST [12]	Learner's Level of knowledge, Media preferences, learning goals
Oscar CITS [13]	Learner's level of knowledge, dimensions of the Felder-Silverman learning style

As shown in table 1, the presented systems combine at most three personalization parameters to serve a personalized learning strategy. However, there are several combinations of personalization parameters which have not been applied yet on a given course. Therefore, the next section investigates the proposed methods to select the appropriate personalization strategy for a given course.

2.2 Personalization Strategies

Before applying a personalization strategy for a particular course, the teacher has to select the combination of personalization parameters to use. There are 524287 $=\sum_{i=1}^{19} C_1^{19}$ possible combinations when considering the subset of personalization parameters generated from the 19 personalization parameters presented in [4]. Thus, the selection of the personalization strategy to apply for a particular course could be based on the personalization parameters that require less creation of extra LO by the teacher. In this context, some research works, in the literature, proposed some techniques for rating the personalization parameters according to the available LOs in a given course. For example, Essalmi et al. presented in [14] four metrics for evaluating the personalization parameters according to the available LO, namely CRCH, CRP, CRCHDegree and CRPDegree. In particular, CRCH and CRP are based on Boolean logic. However, CRCHDegree and CRPDegree are based on fuzzy logic. Furthermore, Essalmi et al. presented metrics which aim to evaluate the personalization strategies composed of more than one personalization parameter [4].

The next section presents a new system which analyzes the given personalization parameters and select the appropriate combination of parameters to use in a personalization learning strategy.

3 MSPSS System

To simplify the task of a teacher when it comes to selecting the appropriate personalization strategy for a given course, a web-based system called Most Suitable Personalization Strategy Selector (MSPSS) is developed. The main objective of this system is to guide the teacher's decision regarding the appropriate combination of personalization parameters to use in personalization strategy of a course. The proposed system is based on Dynamic Programming which is an algorithmic method formalized by the mathematician Richard Bellman in the 1950s [15] for solving complex optimization problems by breaking them down into a number of overlapping sub-problems. This method is used in many domains, such as image processing [16] and bioinformatics [17, 18]. MSPSS uses two values which are as follows:

Satisfaction value: It is calculated based on the availability of LOs of a given course according to a personalization parameter. This value ranges from 0 (no LO available for the learner characters) to 1 (each learner character has a LO). In this context, Essalmi et al. proposed in [14] a CRCH metric which calculates the satisfaction value of six personalization parameters within the Microsoft Excel course. These values are presented in table 2.

Table 2. Satisfaction value of the personalization parameters in the Microsoft Excel course.

Personalization parameters	Satisfaction value
Learner's level of knowledge	0.37
Media preference	0.87
Honey & Mumford learning style	0.27
Active/reflective dimension of Felder– Silverman learning style	0.87
Sequential/Global dimension of Felder– Silverman learning style	0
Visual/verbal dimension of Felder– Silverman learning style	0.56

Assessment time value: It is the time that a learner could spend answering a questionnaire regarding a personalization parameter. This value could vary from a questionnaire (or test) to another. To define each assessment time value within MSPSS, 35 learners (25 girls, 10 boys) from a public university in Tunisia have participated in an experiment where they answered different assessment questionnaires regarding the different personalization parameters presented in table 2. Then, for each questionnaire, the average assessment time value is calculated. These values are presented in table 3.

Table 3. Assessment time value of the personalization parameters.

Personalization parameters	Assessment tests	Assessment Time value
Learner's level of knowledge	Microsoft Excel test	6
Media preference	Affective profile questionnaire [21]	1
Honey & Mumford learning style	Learning style questionnaire [20]	15
Active/reflective dimension of Felder– Silverman learning style	Index of learning style questionnaire [19]	3
Sequential/Global dimension of Felder– Silverman learning style	Index of learning style questionnaire [19]	3
Visual/verbal dimension of Felder– Silverman learning style	Index of learning style questionnaire [19]	3

To select the most appropriate personalization strategy, MSPSS chooses the personalization parameters which have the highest satisfaction value within a course and also the lowest assessment time. Table 4 presents an example of an input, using the six personalization parameters (i), which is given to MSPSS regarding Microsoft Excel course.

Table 4. Example of an MSPSS input according to the Microsoft Excel course.

i	Personalization parameters	Satisfaction value (vi)	Assessment time value (wi)
1	Learner's level of knowledge	0.37	6
2	Media preference	0.87	1
3	Honey & Mumford learning style	0.27	15
4	Active/reflective dimension of Felder– Silverman learning style	0.87	3
5	Sequential/Global dimension of Felder– Silverman learning style	0	3
6	Visual/verbal dimension of Felder– Silverman learning style	0.56	3

Using the dynamic programming, this optimization problem will be solved as follows: the teacher starts by fixing the maximum assessment time that the learner should not pass (for example, W = 7 minutes), then, the dynamic programming matrix will be filled using the recursive definition [22] as shown in (1) bellow, from left to right, up to bottom.

$$m[i,w] = \begin{cases} 0 & if\ i = 0 \\ m(i-1,w) & if\ w_i > w \\ \max\{\, m(i-1,w), m(i-1,w-w_i) + v_i\} & if\ w_i \leq w \end{cases} \quad (1)$$

i: It is the number of each personalization parameter (as shown in table 4, i ranges from 1 to 6).
w_i: It is the satisfaction value of the personalization parameter i.
v_i: It is the assessment time value of the personalization parameter i.
w: It is the maximum assessment time given by a teacher (in this case 7min).

Table 5 presents the obtained Dynamic Programming matrix of the example presented in table 4. The personalization parameters are presented, in rows, numerated from 0 (initialization) to 6 while, the remaining time (w) is presented in columns. Finally, the optimal result is obtained with a recursive trace-back of the matrix starting from the last cell (Repeat for i = n to 1; if m [i, w] > m [i - 1, w] then the parameter i is included in the strategy, w= w - w_i; else i is not included).

Table 5. The obtained dynamic programming matrix**.**

i\w	0	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0.37	0.37
2	0	0.87	0.87	0.87	0.87	0.87	0.87	1.24
3	0	0.87	0.87	0.87	0.87	0.87	0.87	1.24
4	0	0.87	0.87	0.87	1.74	1.74	1.74	1.74
5	0	0.87	0.87	0.87	1.74	1.74	1.74	1.74
6	0	0.87	0.87	0.87	1.74	1.74	1.74	2.3

As shown in Table 5, the selected personalization parameters after applying the proposed method are: Media preference (i= 2), Active/reflective dimension of Felder–Silverman learning style (i= 4), Visual/verbal dimension of Felder–Silverman learning style (i= 6). Figure 1 presents the obtained results using MSPSS. The three appropriate personalization parameters (media preference, Active/reflective dimension of Felder–Silverman learning style and Visual/verbal dimension of Felder–Silverman learning style) are highlighted in green.

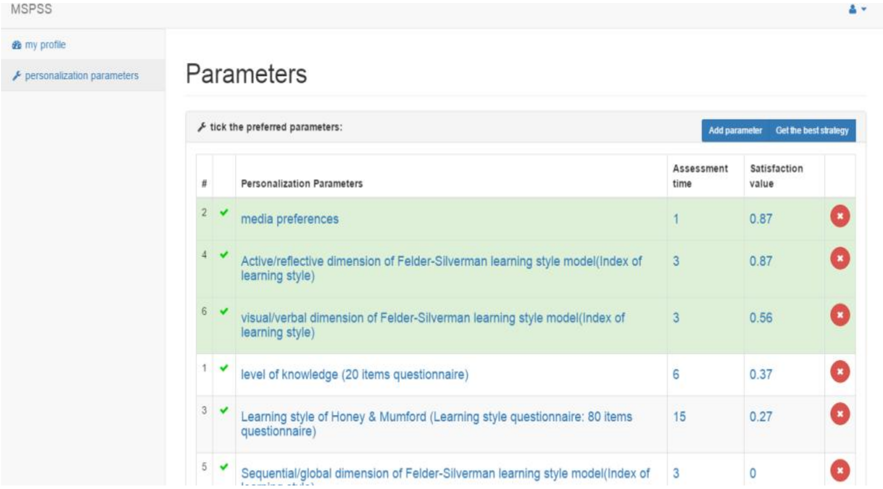

Fig. 1. Screenshot of the obtained result using MSPSS system.

4 Experiment

This section validates the proposed system MSPSS. In particular, section 4.1 introduces the participants of the conducted experiment and presents the followed procedure. Section 4.2 presents the used research instrument to validate the system. Finally, section 4.3 lists the obtained results.

4.1 Participants

Thirty one computer science student-teachers from a public university in Tunisia participated in validating MSPSS. They are all familiar with e-learning and personalized learning research areas. At first, these student-teachers took an overview about the main objective of this experiment. Then, they all used the MSPSS to select an appropriate personalization strategy for a given course. Finally, their level of satisfaction toward the system was evaluated. The next section presents the used instrument to evaluate the participants' level of satisfaction towards MSPSS.

4.2 Instrument

To evaluate the student-teachers' level of satisfaction after using MSPSS, they were asked to answer a Technology Acceptance Model (TAM) questionnaire. They had to answer by giving points which range from 1: Strongly agree to 5: Strongly disagree. TAM is a widely used model in information science [23]. Besides, it has been used to validate different application such as electronic courseware [24] and multimedia learning environment [25]. The questionnaire covers the four variables of TAM which are [26]: (1) Ease of use (EOU) which defines the degree to which the student-teachers find the system easy to use and free of effort, (2) Usefulness (U) which defines the degree to which the student-teachers think that the system will help them select the best personalization strategy for a given course, (3) Attitude towards using the system (ATT) which defines the degree to which the student-teachers report a favorable and positive attitude towards the system after using it and, (4) Intention to use the system (INT) which defines the degree to which the student-teachers are willing to use the system again in the future to select the suitable personalization strategy for a given course.

4.3 Results

The medians and averages of the student-teachers' answers to the questionnaire are calculated. In general, an average and median near 1 indicate that they are satisfied with MSPSS. However, an average and median near 5 indicate that the student-teachers are dissatisfied with MSPSS. Table 6 lists the values of medians and averages for the variables EOU, U, ATT and INT.

Table 6. Average and medians of user's satisfaction while using the MSPSS system.

	U	**EOU**	**ATT**	**INT**
Average	1.58	1.95	1.66	2.17
Median	1.00	2.00	1.00	2.00

As shown in table 6, the student-teachers were satisfied while using MSPSS since the averages and medians are far from 5 and range between 1 and 2. For instance, the average of the student-teachers' attitude toward using the system is equal to 1.66, while the median is equal to 1.

5 Conclusion, Limits and Future directions

This paper presented a new system called MSPSS which can help teachers select the appropriate personalization strategy for a particular course. The proposed system is based on the dynamic programming method which is widely used in the operations research field for solving complex optimization problems. In particular, MSPSS chooses the personalization parameters which have the highest satisfaction value within a course and also the lowest assessment time.

MSPSS was evaluated by thirty one student-teachers using TAM questionnaire. The obtained results were very promising. In particular, they found the system, useful and easy to use. Besides, they reported that they have a favorable attitude toward the system and they are willing to use it in the future to select the appropriate personalization strategy of a given course.

On the other hand, some limitations which may limit the generalizability of the results are found. For example, the selected personalization strategy using MSPSS of the given course Microsoft Excel was not evaluated with students. Consequently, their feedback regarding the effectiveness of the proposed personalization learning strategy was not collected.

Future directions focus on evaluating the personalized learning strategy selected by the system MSPSS. This allows investigating the effectiveness of the proposed system when it comes to the selection of the appropriate personalization strategy. Besides, further metrics which allow calculating the satisfaction value will be implemented within MSPSS. Consequently, compare the obtained personalization strategies using different metrics.

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A Conceptual Framework for a Smart Learning Engine

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Abstract. Learning activities and environments have changed dramatically in the last 50 years, in large part due to information and communications technologies. New technologies make it possible to create a smart learning engine in the form of an intelligent personalized learning system that can be integrated with a variety of interaction devices. In addition, on the instructional design and personalization/customization side of things, a smart learning environment can structure or recommend specific interactions for individual learners based on subject matter, learning goals and a learner's preferences, interests, ability, and knowledge. This means that a smart learning environment can develop meaningful learning pathways for individual learners and create optimal learning activities to help learners attain intended goals by deploying suitable learning resources and interactive tools to enhance learning, performance, and the student's experience.

Keywords Leaning environment; Smart learning; Intelligent tutoring system

1 Introduction

Smart learning environments (SLEs) herein are defined as active learning places that can be used to access and structure learning content, sense specific learning contexts and goals, identify a particular learner's abilities and needs, provide relevant learning resources and interactive tools, automatically record learning process and evaluate learning accomplishments so as to promote efficient learning [1]. This is an ambitious list of capabilities, but individual parts of such an

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environment have already been created and demonstrated. An integrated, interactive and intelligent (i^3) system has yet to be fully developed and deployed, but that is the goal of the effort reported herein. In the 21st century, new learning systems are being developed at an increasing pace to take advantage of powerful new technologies, such as the JuxtaLearn system (ClipIt) [2]. Many more powerful new learning technologies and environments could be mentioned, but they introduce a new challenge for teachers – namely, the challenge of identifying the appropriate tools or technology to use with specific learners in a variety of learning situations. The teacher task is becoming increasing more difficult as these systems proliferate.

In response to this challenge, we propose an i^3 (integrated, interactive, intelligent) system that can support both students and teachers amid the technology challenges of the 21st century. In this paper, a Smart Learning Engine (SLEng) is proposed as the core of an i^3 SLE. We propose a theoretically-grounded and empirically informed conceptual framework that features an intelligent personalized learning system for the improvement of teachers and learners by integrating different systems together and providing services for different learning scenarios and content.

2 Relevant Research

One could argue that the first SLE and associated education engine was the Programmed Logic for Automatic Teaching Operations (PLATO) created at the University of Illinois. PLATO was the first computer-based education system and the home of the first online learning community (albeit through networked learning labs and local area networks initially). PLATO provided a means for individualized student instruction and opened the door for interactive computer education. Online education would not be where it is today without the development of PLATO [3].

ITSs (Intelligent Tutoring Systems), also called cognitive tutors, were developed to guide learners through a learning process [4]. These systems can be used in the traditional educational settings or in distant learning courses, either operating on stand-alone computer or as applications that deliver knowledge through the Internet. An ITS can provide adaptive support for student problem solving or question answering activities in a variety of well-structured domains. Sleeman and Brown reviewed the state of the art in computer-aided instruction and first coined the term 'ITS' to describe these evolving systems and distinguish them from the previous CAI systems [3]. ITS research has successfully delivered techniques and systems that provide adaptive support for student to improve problem solving abilities in domains that are well-structured with clearly defined problems and learning outcomes.

While an ITS typically had an extensive bug library (database of common misconceptions and errors), there was no way to extend that library or build on the experience of learners in responding to various forms of automated remediation. Moreover, learners have a variety of predispositions, interests and moods, and they are influenced by external factors such as prior knowledge, types of tasks, and facilitation; these factors can affect their learning progress [5]. In response to that shortcoming, a SLE should not only be integrated and interactive, it should be intelligent and improve its performance over time based on how large numbers of learners are doing in various learning situations. As a result, learning analytics can be used to recommend activities and resources based on how similar learners similarly situated have performed when using those resources and engaging in those activities [6]. The SLEng proposed herein contains the ability to improve over time based on learning analytics, which means that it will be able to support an i^3 SLE.

3 Components of the Conceptual Framework

The SLEng has some similarities with an ITS; both of them can track students' learning, tailor personalized feedback, or suggest teaching strategies for fitting learning and teaching needs. The SLEng described herein can integrate different educational systems, resources, tools and delivery mechanisms, improve in performance based on the experiences of prior learners using those resources, and can consider the learner in a more holistic manner, including interests, preferences, predispositions as well as prior knowledge and ability. The SLEng consists of three main functions: (a) I - identifying relevant data about the subject, the environment and the user, (b) C - computing an appropriate learning pathway, and (c) D - deploying suitable resources for students and the teacher. The SLEng will make use of prior research and theory to create engaging, effective and efficient learning experiences (e3 learning). Three main functions are descripted as follows.

Identifying (I component). The main concept of the I component is to identify data from student, teacher, subject area, and the environment using wireless sensors, the established learning resources and scenarios, and a learner modeling technology. The acquired data includes learned prior knowledge, theme-based knowledge and aspects of the physical learning environment which then inform the C and D components.

Computing (C component). By identifying learner's characteristics, study status and study situation will then compute an optimal learning process, a learning pathway, and also predict student's action. The C component can compute which kind of resources the learner will need and calculate an appropriate way of learning. Therefore, based on the results of identifying component, the C component of SLEng could model users' affective data, build complete structure for descripting each domain knowledge, optimize the knowledge module for adapting the individuals, and connecting between users' data from learning community.

Deploying (D component). According to common misconceptions and individual needs of students and teachers, the D component will automatically deploy the most suitable strategy, resources and tools for students and teachers. In order to stimulate students' learning enthusiasm, let them have a higher learning incentives and learning effectives through SLEng, deploy appropriate resources is indispensable. Therefore, the main ideal of the D component is to accord the users' personal features to deliver the personalized and adaptive supports for students as well as teachers.

4 Implementation and Evaluation Plans

The overall goal of the SLEng is to improve learning and teaching, especially in K-12 settings. As this is a conceptual framework, the next step of the implementation plan is to develop a prototype based on a SLEng containing **ICD** components to verify whether we can build such comprehensive system and whether we can integrate various technologies effectively in a single system. The second stage is to evaluate the implemented prototype by conducting the feasibility studies on the I, C and D components of this prototype and then optimize the prototype based on the data from investing the people who use the prototype system. Each feasibility study will inform subsequent feasibility and usability studies. However, since the SLEng proposed in this study is still in early stage of development, more system stability is anticipated to better facilitate their learning.

This system is being tested in a laboratory setting using representative teachers from a number of primary and secondary schools. The initial test domain is Learning English as a Second Language as this subject is emphasized and lends itself to personalized learning quite well. The second test domain is likely to be mathematics so as to test the i^3 system with a totally different subject matter. On the output side, some of the components are already being tested in school settings. The evaluation will include obvious measures such as learning outcomes and student performance as well as sustainability measures such as teachers' abilities to modify and customize resources and activities using tools integrated within the system.

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Investigation of Key School-related Indicators Influencing ICT in K-12 Education

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Abstract: In the first phase, Delphi technique was conducted to identify key indicators influencing promotion ICT in K-12 schools settings. The result of the qualitative phase revealed that ICT leadership development, teacher professional development, optimized learning spaces, richness of digital resources, innovative ways of teaching and learning, changes in learning assessment forms six key indicators for ICT in K-12 education. At the second phase of the research, cases from China were selected and scored in each six indicators, and path modeling was built. The findings of this research provide important implications for the evaluation and improvement of the process of ICT reshaping K-12 Education.

Keywords: *ICT in Education; educational change; influencing factors; path model*

1. Introduction

Multiple previous studies have showed that, ICT integration into classroom is a slow and complex process that is influenced by many factors(Levin & Wadmany, 2008). Studies have found that teacher's computer use in years, lack of time, teaching experience, teacher attitude and technology competencies are five elements affecting ICT contribution to K-12 education. Unlike existing research, this research aimed to build a path model at school level for promoting ICT in K-12 education. Consequently, at the first stage of the research, a Delphi technique was conducted to identify school-related indicators for ICT in K-12 education. At the second stage of the research, 40 cases from China were selected to be evaluated by

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each identified indicators, and a model for ICT integrating into K-12 schools was built by modeling approach.

2. Methodology

Research questions

- How to profile and analyze the process of ICT infusing in K-12 education?
- What are the key school-related factors influencing ICT integration into K-12 education? And what are the relations betweenthem ?

The first stage of the research: Delphi technique

To select the panelists, the study used two types of non-random sampling, and sampling size was 30 panel members. The Delphi technique in this research included two rounds. In round 1, 30 semi-structured face-to-face interviews with panel members were conducted to explore the key indicators influencing ICT in education in school settings. After interviews, the opinions of the panelists were summarized, selected, and transformed by coding and indexing, and then the obtained data were categorized and compared with the key indicators from literature review. The opinions of the panelists were summarized, and all the indicators from round 1 and literature review were included in the questionnaire of round 2.

In round 2, panelists were asked to determine the degree of importance of indicators based on the five point Likert scale from 1= not important to 5= extremely important to get a consensus on the key indicators that influencing ICT in K-12 school settings. The data of round 1 were analyzed by coding and indexing, and those of round 2 were analyzed using Content Validity Ratio (CVR).

The second stage of the research: case selecting, scoring and analysis

In the second phase of the study, 30 cases (10 primary schools, 10 junior high schools and 10 senior high schools) were selected from pool of the elite schools identified by China Association of Educational Technology and China Education Daily. Then 10 experts in the first research stage were invited to scoring the cases in aspects of the identified key factors. Documents of the selected case were provided to them, and they scored the cases in Likert 5-point scale (1-poor; 2-not good; 3-on average; 4-good; 5-very good). Then data were collected and analyzed using path analysis to build a path model.

4. Findings

4.1 Research findings from the Delphi technique

Table 1 shows the frequency of panelists mentioning the indicators, also the definition of each indicators were made clear to the experts.

Table 1 Indicators identified by Delphi panel members

N.	Indicators	Frequency			
		school leaders (n=17)	government officers (n=3)	researchers (n=10)	Total (n=30)
1	ICT leadership	15	3	9	27
2	Digital learning resources	10	2	9	21
3	Teacher professional development	11	3	6	20
4	Learning spaces	17	2	7	26
5	Learning assessment	9	2	6	17
6	Pedagogies and learning approaches	12	2	8	22
7	e-learning culture	3	1	3	7
8	Technical support	12	1	6	19

At the second round of Delphi, the degree of the importance for each 8 indicators in table 1 was scored by the panelists. And the CVR was calculated using the following formula:

$$\text{Content Validity Ratio(CVR)} = \frac{n_e - \frac{N}{2}}{\frac{N}{2}}$$

4.2 Research findings from path analysis

4.2.1 Preliminary analysis: data screening, correlations, assumptions

The data of the cases were not missing completely in respect to the six indicators that influence ICT in education.

Examination of the bivariate correlations between variables (see Table3) was

Pearson product-moment correlations between measure of indicators

Indicators	1	2	3	4	5	6	7
(1) ICT leadership	1						
(2) Development of ICT in Education	.271	1					
(3)Teacher professional development	.057	-.010	1				
(4) Pedagogies and learning approaches	.185	.317*	.037	1			
(5) Learning spaces	.110	.208	-.088	.519**	1		
(6)Digital resources	.136	.000	.083	.342*	.379*	1	
(7) Learning assessment	.171	.262	.298	.043	.431**	.157	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

used to inform a prior idea about the nature of the relationships among the variables.

4.2.2 Path modeling

As shown in Figure 1, ICT leadership and teacher professional development are exogenous variables; learning spaces, digital resources, learning assessment, pedagogies and learning approaches and development of ICT in education are endogenous variables in the model. The estimated path coefficients are also presented.

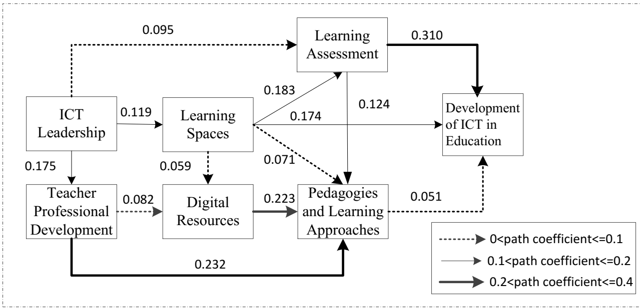

Figure 1 Path analysis results: The estimated path coefficients, *p<.01, two-tailed

5. Conclusion and discussion

This research identified six factors that influence ICT in K-12 education at school level. They are ICT leadership, teacher professional development, digital resources, learning spaces, pedagogies and learning approaches, learning assessment. The process of ICT development in K-12 education highly depends on changes of learning assessment, innovative pedagogies and learning approaches, and teacher professional development, while changes in pedagogies and learning approaches depends on the optimizing of learning spaces and richness of digital resources.

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Towards a Reference Architecture for Smart and Personal Learning Environments

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Abstract. Personal learning environments (PLEs) evolved as a response to the limitations on self-regulated learning posed by institutional control of learning environments, such as Learning Management Systems. Smart learning environments (SLEs) have more recently come to refer to various technological enhancements of learning environments. However, there is a tension between 'personal' and 'smart', which this paper investigates through the experiences of the TELL ME project. The project focused on the learning of blue-collar workers in Europe's manufacturing sector. The resulting aim was to support the awareness of 'intentions' and 'realizations' and the reciprocities between these across five phases, collectively referred to as MEMO-E: mix, enquire, match, optimize, and experience. Perspectives of the project on the themes, interactions, and philosophy of SLEs and PLEs are explained, a framework for intentions and realizations is introduced, and the characteristics of an evolvable reference architecture for smart and personal learning environments are presented.

Keywords: Personal Learning Environments · Smart Learning Environments · Service-Oriented Architecture · Resource-Oriented Architecture · Augmented Reality · Performance Augmentation · Self-Regulated Learning · Agency

1 Introduction

Personal learning environments (PLEs) have evolved as a response to the limitations on the role of the learner posed by institutional control of environments such as Learning Management Systems [1], especially in terms of self-regulation. Smart learning environments (SLEs) have been defined as physical environments "with digital, context-aware and adaptive devices, to promote better and faster learning" [2]. However, there is a tension between 'personal' and 'smart', which can be illustrated by an analogy with personal computers and smartphones at their

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respective times of introduction. Personal computers represented a move away from institutional dependency and control, e.g., as opposed to the use of institutional mainframes. Smartphones reintroduced dependencies, but in new guises, e.g., centralized cloud services. From this followed the associated tracking of users and new modes of control such as by manufacturers, service providers, and to a lesser extent institutions; cf. the seemingly unstoppable practice of bring-your-own-device. This paper aims to investigate some of the tensions between PLEs and SLEs, through the experiences of the project Technology-Enhanced Learning Livinglab in Manufacturing Environments (TELL ME; see Acknowledgements).

Current research and development have yet to fully realize the visions of PLEs and SLEs, especially from a learner perspective (see e.g., [3] and [4] for state-of-the-art and visions of respectively PLEs and SLEs). In terms of ownership and associated agency (freedom of choice as to use made of it), an institutionally owned PLE is not personal from the perspective of the learner. Similarly, an institutionally owned SLE can be 'smart' from the perspective of the owner, e.g., by tracking and monitoring of learners, as part of achieving the goals of the SLE owners. But this is not necessarily being smart from the perspective of a learner, who may prefer not to be tracked but wishes to set higher personal goals, e.g., to innovate (*learn better things, LBT*) or to develop self-regulation skills (*learn things better, LTB*). LBT and LTB can each involve learner-controlled exploration of variations in what is learned and how it is learned. In summary, a learner should benefit from the learning environment according to her or his own individual needs and wishes. As stated by Kinshuk et al. [4] concerning SLEs, they should "engage and integrate formal and informal learning in order to create autonomous adaptive learning environments for supporting individual learners with real-time and seamless learning experiences in ubiquitous settings".

In our project, which focused on Technology-Enhanced Learning in manufacturing environments, there was similarly a need to achieve a balance between increased adaptability for individual learners on the one hand and fulfilling specific project-wide objectives on the other. There was also a need to balance personal ownership and control of resources with more easily implemented but centralized architectures. In order to achieve these balances, we took a dual approach: less adaptability and more centralization for testing and evaluation here and now, and steps towards a reference architecture that could capture both the centralized architecture and later a more 'personal' and 'smart' distributed architecture, from the perspectives of the learners.

The resulting aim of the project can be summarized as the awareness of *intentions* and *realizations* across five phases, collectively referred to as MEMO-E: *mix*, *enquire*, *match*, *optimize*, and *experience*. Generally, awareness of intentions means to help a learner to make correct, or precise, evaluations and therefore to intend the right things, e.g., what actions to take in order to carry out assigned work tasks. Awareness of realizations, then, means to help a learner to perform correct executions of what is intended, e.g., performing precisely those actions that are intended and doing so with sufficient precision.

Each of the phases emphasizes intentions and realizations differently. *Experience* is most closely associated with realization, and *enquire* with intention. *Mix* and *match* relate to selection of intentions and realizations, and *optimize* with how the selection is made, e.g., through various metrics on which to optimize. Also, multiple phases may be active at the same time, while for the most part remaining latent without requiring the learner's immediate attention. E.g., if, in the experience phase, an error is made when performing an action, optimization results in new selections of intentions and realizations, for instance an immediate, new action to recover from the error and/or a later refresh on how to perform the original action, which is to be realized through use of learning objects such as a tutorial video.

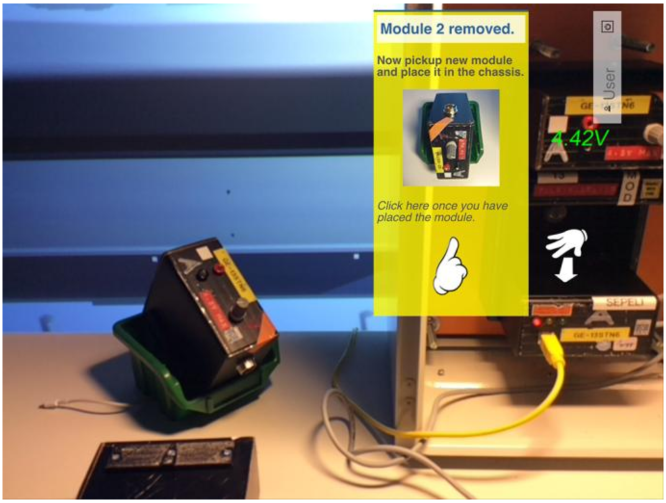

Fig. 1. *ARgh!* supporting a learner to perform correct evaluation and execution during the experience of a simulated work task

Fig. 1 and Fig. 2 highlight two different attempts to meet the project aim. The first shows an Augmented Reality (AR) application, called *ARgh!*, which is based on a data exchange standard [5] in development at IEEE under the working name Augmented Reality Learning Experience Model (ARLEM). The second is a Web application, called *Spacify*, which is a prototype learning environment augmented with a button for an expandable sidebar, which in turn is called *Placify*. The idea is that *Placify* could, in the future, be used to augment various learning and work environments, including hybrids thereof [6], with MEMO-E functionality, and that *Spacify* would be a foundation on which to construct such environments.

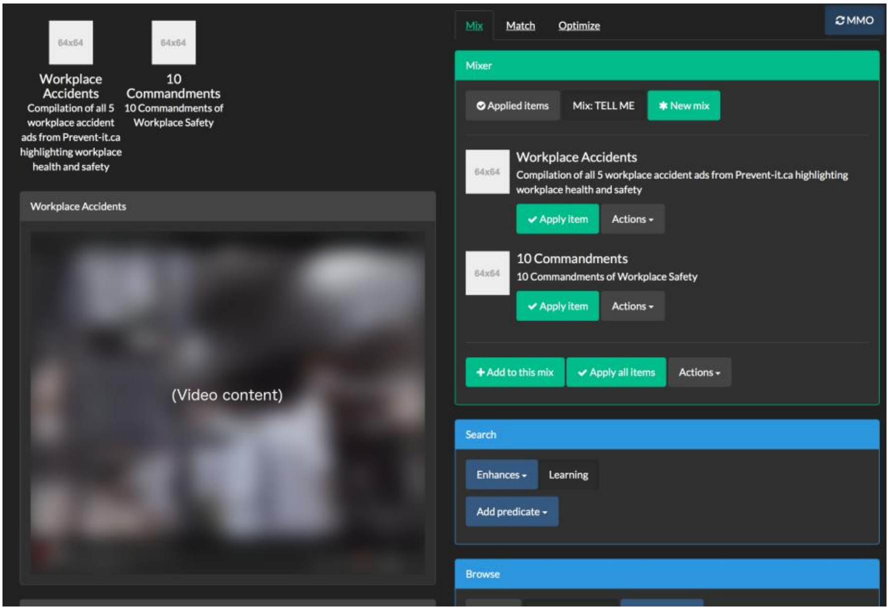

Fig. 2. *Spacify* is on the left half of the page and *Placify* is expanded on the right half of the page. The 'MMO' button in the top-right corner refers to Mix-Match-Optimize, a subset of MEMO-E. When clicked, the button expands or collapses *Placify*. The button can also used to provide MMO-related real-time notifications when the sidebar is collapsed.

The remainder of the paper will follow a similar approach to Johnson et al. [1] with three strata of investigation: discursive themes, interactions (patterns in [1]), and a philosophical perspective. In the case of this paper, the investigation is based on the authors' experiences in the TELL ME project, with the aim being to characterize a reference architecture for smart and personal learning environments. As such, this paper adds an SLE perspective to what is already stated for PLEs in [1].

2 Themes

In the TELL ME project, learning environments were regarded as simultaneously involving three worlds: real, digital, and virtual. The real world consists of physical objects and spaces, increasingly instrumented and amenable to Artificial Intelligence (AI) monitoring and linking to learning environments through the Internet of Things (IoT). The digital world consists of software including apps and services, mediating between the real and virtual. The virtual world consists of non-physical objects such as learning objects that can be represented digitally. It presented a major challenge to integrate these worlds into an architecture that could evolve in response to the changing needs of learners, in TELL ME notably blue-collar workers. Due to rapidly changing business conditions, learning that involves up-skilling and re-skilling as well as encourages creativity becomes important in order to remain competitive.

Relative to larger enterprises, small and medium-sized enterprises are normally less capable of introducing advanced technology-enhanced learning on their own. Hence, the focus of TELL ME was on SMEs in Europe's manufacturing sector. Being a rapidly evolving and at the same time (in Europe) at-risk sector, manufacturing faces particular challenges of maintaining relevant skills and therefore competitiveness. Addressing these challenges, the three pilot studies carried out in TELL ME involved specialized textile industry in Germany, luxury boat furnishing in Spain, and helicopter maintenance in Italy.

Among the different issues thus faced by the project were:

1. The confusion of real, digital, analog, and virtual (with a focus in TELL ME more on digital mediation and less on analog mediation)
2. Technological integration
3. Architectural evolvability
4. Deployment in high-security and non-networked settings
5. Adaptivity and adaptability on an individual level (personalization)
6. Motivation to learn among blue-collar workers
7. Encouraging blue-collar workers to be creative
8. Privacy concerns of learners
9. Human factors and well-being
10. How do learners fit into the architecture?

3 Interactions

Interactions between the real and the virtual can be mediated either by digital or analog technology, or various hybrid combinations of these. Whereas PLEs have emphasized the digital objects of interactions, SLEs increasingly emphasize real objects. Illustrating mostly the latter and some of the former, symbols for various interactions supported by the *ARgh!* app are shown in Fig. 3.

As for virtual interactions, TELL ME primarily took inspiration from service architectures. Virtualization has been a topic in computing for decades, starting with operating systems that allowed multiple users to use the same system simultaneously, with every user in effect having access to her or his own 'virtual' machine. More recently, virtualization has enabled cloud computing such as Infrastructure as a Service (IaaS) where computing resources are offered virtually and on-demand, using pools of real computing resources, which can then be utilized with greater efficiency. Beyond IaaS, there are Platform as a Service (PaaS) providing environments for building applications *using* the cloud and Software as a Service (SaaS) for applications that are themselves *in* the cloud. [7]

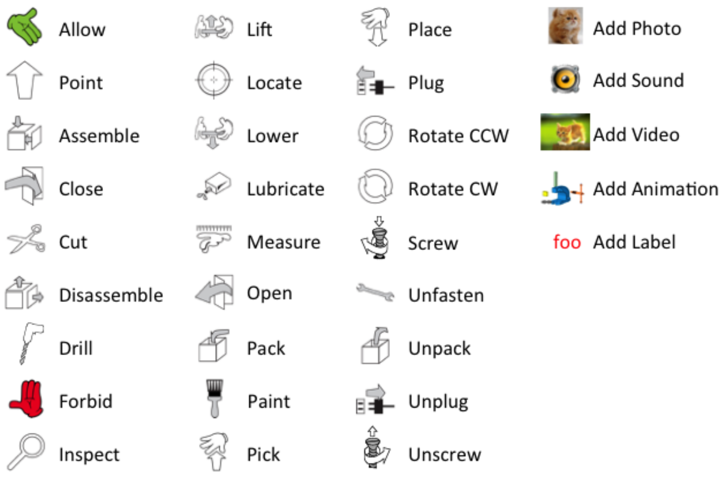

Fig. 3. *ARgh!* system verbs in symbol form

By taking virtualization beyond IaaS, PaaS, SaaS, and others such as Knowledge as a Service (KaaS; e.g., IBM's Watson and similar cloud services in manufacturing and associated training, used to model and refine a manufacturing or maintenance process or to explore how a competitor might be achieving greater efficiency), one could eventually arrive at Anything as a Service, XaaS, which we interpret as the possibility of virtualization of *anything*. For the purposes of this paper, virtual interactions are, then, interactions with such virtual *things*. These interactions are digitally mediated, so are able to take any form and could therefore from a learner's perspective reflect real interactions (see Fig. 4). To some extent, this is what WIMP (Window, Icon, Menu, and Pointer) user interfaces already do, through the application of a desktop metaphor.

In its capacity as digital mediator, software deals with digital representations and descriptions of objects that are virtual, i.e., not real. As such, the virtual objects contain embedded intentions (through their intended meanings), which are then realized and mediated using digital technology. Through XaaS (see, e.g., [8] for existing use of the term), anything could be virtualized anywhere, while applied in the context of any environment. This digital mediation enables a greater degree of flexibility in adapting interactions to learners. Moreover, AR is increasingly employed to produce a blend of the real and virtual, as an aggregation, which contains any suitable mix of real and virtual objects. In this blend, objects can augment other objects, producing augmented objects.

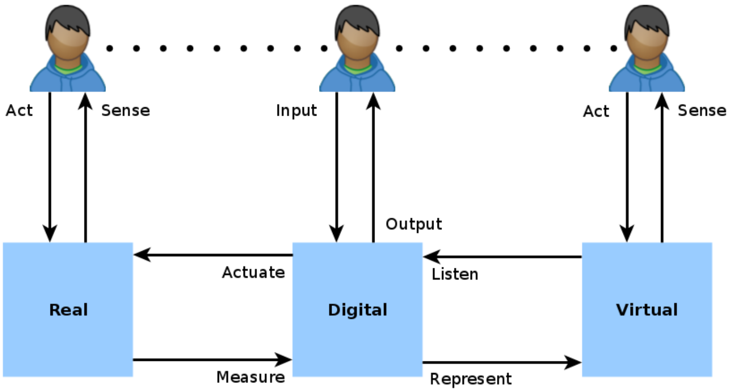

Fig. 4. Real, digital, and virtual interactions in SLEs, with arrows indicating information flow and label alignments indicating agency

Consider the initial ease of learning the multi-touch UI of a tablet, as a natural user interface (NUI) which closely matches real world interactions [9]. Beginners could initially be offered more simple and natural interactions, changed to increasingly sophisticated interactions as skills increase. Recent advances in machine learning further enhance this trend, with computers becoming increasingly able to sense human expressions as well as physical environments in similar ways to humans.

4 Philosophy

Johnson et al. [1] refer to "Heidegger's characterisation of a 'tool' as something which specifically presents a physical instrumental component to the user, as well as being something with which *doing* is achieved". They further go on to say that "'knowing how to use' is a combination of ability with an instrument and knowledge of what to do with it". Moreover, one can distinguish between Heidegger's present-at-hand and ready-to-hand, i.e., respectively to reflect (or theorize) about a something and to use something without theorizing (i.e., being absorbed) [10]. In particular for hybrid learning and work environments, such as in the case of TELL ME, SLEs can enhance readiness-to-hand through adaptive tools and methods such as Precision Teaching (PT), while recognizing that presence-at-hand will at times be necessary, such as when reflecting on errors. This is comparable to the *depunctualization* of an actor-network when it breaks down, upon which the 'black box' is opened and its contents can be studied [11].

Concerning services, Johnson et al. [1] refer to "separability between service and instrument [that] allows for significant reorganisational change", specifically allowing, on the one hand, "for the reduction of 'redundancy of functionality' typified by monolithic systems (and e-learning systems), whilst on the other it allows for the possibility that users themselves may be able to define their own instrumentation whilst accessing common services". E.g., the PLE implementations of the ROLE project used widgets in order to allow learners to choose the tools that they prefer, as instruments for accessing common services [12,13]. Widgets could be created by anyone, including learners themselves for their own use, and shared with other learners. By contrast, in TELL ME's conception of SLEs, increasingly everything is being instrumented, e.g., through AR. Underneath such learner-oriented instrumentation, services remain as a machine-level instrumentation of *things*, e.g., as in the Internet of Things. Hence, rather than services, it is *things*—whether real or virtual—that are "at the bottom" of the conceptual stack.

5 Architecture

Bringing together the discussions of the previous sections, TELL ME specified a framework of intentions and realizations and an architecture in which these could be deployed. In order to explain the framework, we refer back to *Spacify* and *Placify* that were mentioned in the introduction (Fig. 2). The particular mix that makes up the view in *Spacify* is called the 'space', as a generic term for workspace and/or learning-space. It consists of a mixture of intentions and their realizations, which are related in ways that reflect the underlying business and learning model.

From the perspective of *Placify*, each intention acts as a *realizational placeholder* upon which different realizations of it can be placed. Dually, each realization acts as an intentional placeholder upon which different intentions can be placed. Different intentions correspond to different ways of answering the question of *why* we are using a certain realization, and different realizations correspond to different ways of answering the question of *how* we are realizing the intention. A space (noun), then, represents an intentional scheme of related realizational placeholders, where things realizing the corresponding intentions are to be 'placed'. In our model and in the context of TELL ME, such deployment turns a *workspace* (including, e.g., a training center) into a *workplace* where workers carry out (realize) the intentions, including work tasks, which the corresponding placeholders represent. The sum of all deployments in the space/place makes up a current intentional/realizational model of the learning and work environment.

MMO, referring to mix, match, and optimize, is thus the underlying methodology managing the interplay between intention and realization. *Mixes* in this context consist of sets of 'things' with both intentions and realizations. The things are mixed and *matched* so that their combined intentions are realized as well as possible under the conditions (i.e., within the context) at hand, with valuations of qualities from different points of view (e.g., cost, performance, safety, well-being, etc.). Any selection of the things in the matched mixes can be *optimized* over any mixes of the available valuations.

TELL ME created two architectural ‘realizations’. Both are essentially Web-based and, to different extents, resource-oriented [14]. The main, platform architecture, based on a traditional service-oriented architecture, was essentially ‘set in stone’ at the beginning of the project and difficult to later adapt on the level of individual learners. As such, the mixes and matches were effectively presupposed. The other architecture, rather than itself implementing components and features of the main architecture, instead intends to augment the main architecture by taking a more general approach through the support of ‘things’ (i.e., ‘Anything as a Service’). Each *thing* is instrumented with services and apps, including services based on linked data and recent Web standards [15]. I.e., instead of implementing specific services for certain categories of *things*, all *things* are first implemented in a general way. The architecture then offers the possibility for instrumentation through the addition of common services and apps, which become accessible for any *thing*. With, e.g., *Spacify* and *Placify* being based on this augmented architecture, one could use the mixes of TELL ME’s main architecture as a starting point, and then evolve beyond them, through the framework of intentions and realizations.

6 Conclusion

A reference architecture for smart and personal learning environments should apply a sufficient level of abstraction, e.g., that of ‘things’. Furthermore, these should be sufficiently instrumentable, through machine-oriented services and learner-oriented applications including AR.

Returning to the tension between ‘smart’ and ‘personal’ that was discussed in the introduction, a distributed approach such as through the ‘virtualization’ of things should help ensure that the ideals of PLEs can be maintained, even with increasing smartness in the learning environment. For instance, small single-board computers are increasingly cheap and powerful (e.g., the Raspberry Pi). These could function as points-of-presence on the Internet of Things, both for and under the control of individual learners. Everything of relevance throughout the smart and personal learning environment could be interconnected through such ‘personal’ computers, without necessitating centralized and therefore less personal solutions.

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The ALECSO Smart Learning Framework

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Abstract. The review of existing literature, surveys and studies on the status of smart learning and ICT use in education in Arab countries uncovered disparate levels of readiness and preparedness, embracing both strategic and implementation sides. In that regard, a set of key elements meeting the demands of smart learning in the Arab region need to be defined, namely: policy development, raising awareness and capacity building, technological infrastructure (mobile technology, cloud computing, and smart classroom infrastructure) and open learning. These key elements encompass the basis of the proposed ALECSO Smart Learning Framework. This paper gives an overview of that framework and presents its related projects and activities towards supporting and developing smart learning in Arab countries.

Keywords: ICT in Education, Open Learning, Mobile Technologies, Cloud Computing, Mobile Apps, Smart Learning, OERs, MOOCs

1 INTRODUCTION

The Arab League Educational, Cultural and Scientific Organization (ALECSO) is a specialized organization working within the Arab League, and has a membership of 22 Arab countries. Premised on the values of tolerance, moderation, respect for others and cultural diversity, ALECSO organization coordinate several projects and activities in the Arab region in order to promote education, culture and science. Being involved in the international movement to support and develop education [1], the ALECSO organization endeavors, through the projects that it leads in the Arab region, to improve education and make it more thoughtful, engaged, open, accessible and smarter. According to ALECSO vision and plan for the development of education in the Arab region, the effective use of Information and Communication Technologies (ICT) in education is considered as a primarily avenue allowing to reach not only the objectives of enhancing education and its quality, but also to reach the Sustainable Development Goals SDGs in the long run. There is no doubt that, for a long time ago, education has been changing following the rapid growth of ICT and the tremendous advancements in technologies. This

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rapid evolution makes actually expectations of enhancements in education more pressing. Accordingly, several new learning terms, and notions, and concepts have appeared and used in different contexts, namely, e-learning, online learning, blended learning, mobile learning, pervasive and ubiquitous learning, social learning, flipped classroom, open learning, open educational resources, open licensing, MOOCs, SPOCs, etc. From this perspective, lots of new opportunities in learning context are provided thanks to technologies' advancements, which makes learning process smarter, with further possibilities of individualization, adaptivity, effectiveness, efficiency, engagement, flexibility, thoughtfulness and accessibility [2] [3] [4] [5]. In fact, in the last recent years, the emerging concept of smart learning, aiming initially to make learning more learner-centric, effective, individualized and tailored [6], becomes the new umbrella under which all the aspects related to the effective use of ICT to support smart learning can be placed, including policies and strategies, raising awareness, capacity building, IT infrastructure, educational content, learning tools and environments, etc.[7][8].
Based on the analysis of several surveys and studies on the status of ICT and its use in education in Arab countries, and being involved in a regional and international synergy aiming to enhance education harnessing educational technologies [9], the ALECSO ICT Department, has proposed an entire framework for smart learning empowerment. This framework is based primarily on three key dimensions, namely, open learning, mobile technology, and cloud computing. Each of this highly topical dimension embraces a number of projects. Actually, this framework and all related projects and activities meet very well the mainspring of the organization and its current guidelines since ALECSO is indeed leading the implementation of a "Plan for the Development of Education in the Arab Countries"[1]. The overall goal of this plan is to develop the Arab educational system, mainly through empowering the effective use of ICT in education. This paper gives an overview of the ongoing ALECSO Smart Learning projects, and a profound description of its implementations and related activities. The paper is arranged in the following way: In section 2, we give a quick overview of ICT use in education and smart learning status in the Arab world. In section 3, we describe the ALECSO Smart learning framework, and all underlying projects and activities. Finally, a conclusion is presented.

2 Status of ICT in Education and Smart Learning Readiness in Arab Countries

The review of various literature on the status of ICT and its use in education in Arab countries uncovered disparate levels of readiness and preparedness among various countries. These differences embrace both strategic and implementation aspects. It is also worth noting that existing initiatives in the Arab region are mostly governmental initiatives, sometimes involving partners from the private sector and in some cases non-governmental organizations. Furthermore, a survey was conducted in collaboration between ALECSO and (International Telecommunication Union) ITU, Arab Regional Office, in November 2014, and addressed to both Ministries of ICT and Ministries of Education in the Arab region. This questionnaire survey aims to assess the status of Smart Learning in the Arab countries as a first step towards a new Regional comprehensive Initiative on Smart Learning. This initiative should include all the aspects related to the effective use of ICT in Education, especially harnessing new technologies (e.g. mobile, cloud computing, etc.) to improve access to education and to make the learning process more open, personalized, flexible, thoughtful and engaged. The survey contained questions related to the current state of ICT use in learning and teaching, smart learning strategies, existence of various related policies and the future roadmap, and details of any learner-centered initiatives. In summary, it was reported that there are some strategies already in place in many countries promoting online lessons and assessment in schools, web-based tools and platforms for enhancing educational experience. There are several areas where efforts are currently underway, which would help countries move forward in the realm of smart learning. Authoring tools, digital content development, content repositories, evaluation tools, content quality, etc. are areas with still ongoing efforts. More advance web-based tools for improving classroom education and school administration represent also current priority for some countries. There seems to be a greater recognition towards involving various stakeholders in education process, including parents. While informal learning is not a priority, access to digital content outside of the classroom within the context of formal education is also on the radar. The Survey also revealed emphasis on newer technologies and methodologies, such as Big Data and cloud computing. Several countries also reported national level smart learning pilot projects. However, as seen above, and based on literature, these are isolated initiatives that have not yet materialized into large implementations, or partly implemented but not properly used so that they do not come really to fruition. In the same context, ALECSO, in collaboration with ITU Arab regional office, have conducted a specific study entitled “Guidelines for formulating national strategies on smart learning in Arab countries” [10]. This study aims to provide a holistic view of how various Arab countries can approach towards formulating their national strategies for smart learning, mindful of the aforementioned dimensions, and taking into account existing differences in the preparedness at both national policy and implementation level. A draft of this study was presented in the first ALECSO-ITU Forum on Smart learning held in Dubai in December 2015. In short, based on the analysis of survey findings, the outputs of the study, and the review of literature, a set of key elements meeting the demands of smart learning in the Arab region can be identified, namely : policy development, raising awareness and capacity building, technological infrastructure (mobile access, cloud computing, and smart classroom infrastructure) and open learning. These key elements compose in fact the basis of the proposed ALECSO smart learning Framework.

3 ALECSO Smart Learning Framework

Based on the recommendations issued from the analysis of the ALECSO survey and studies on the status of the ICTs' use in education in Arab countries, and being already involved in a regional and international synergy aiming to enhance education harnessing new technologies, appropriate tools and open educational resources, ALECSO, via its ICT Department, has proposed an entire framework for smart learning empowerment. This framework is based primarily on three dimensions, namely, mobile technology, cloud computing, and open learning. Each of this highly topical dimension embraces a number of projects that we intend to describe briefly in what follows. All of these projects encompass commonly three key milestones: Policies, awareness and capacity building, and technical infrastructure.

3.1 ALECSO Mobile Initiative

In spite of an increasing techie Arab young population, highly interested and even addicted to mobile devices and smartphones, the number of Arabic language based mobile applications developed so far is still few, especially educational applications and serious games. This fact could be explained based on the following:

- Lack of relevant regional initiatives and policies to promote Mobile Technology and mobile learning and to develop the 21st skills, especially for Arab young developers;
- Difficulties to access and reach well-known app stores from Arab countries ;
- Few commercially-successful Arab Mobile markets ;
- Inadequacy of curricula in schools;

Endeavoring to address some of these drawbacks, ALECSO organization has proposed a comprehensive and strategic initiative (ALECSO Apps) aiming to provide the necessary technological and institutional environment for the promotion of an emerging digital creative Arab Mobile industry, related to the fields of education, culture, science and serious games. The ALECSO mobile apps initiative has started in 2015 and it is still running. This initiative involves 22 Arab countries members in the Arab league. Some partners including universities, and ministries of education and ICT, and mobile phone and telecommunication companies in the Arab region are included in this programme. The ALECSO Apps initiative is composed of the following four key component parts [11]:

- ALECSO Apps Store, a web-based application aiming to host and gather Arab Mobile Applications. This platform is also installable on supported mobile devices that run Android OS. This Arab marketplace provides the opportunity to Arab developers involved in Mobile Technology to innovate and to share their creations without any fees, restrictions or barriers.

- ALECSO Apps Editor, a comprehensive mobile applications development Studio enabling users to create their applications in few intuitive steps. The main specificity of ALECSO Apps editor is its ability to build Arabic mobile apps based on a set of embedded easy-to-use tools. The process of generating the final mobile app is done in a transparent way where the user receives the compiled app according the target platform that he specifies.
- ALECSO Apps Award, an annual Pan-Arab competition aiming to motivate and encourage Arab developers to meet high-level standards in terms of Mobile Applications quality, innovation and Entrepreneurship. The competition is set over two stages: The first stage is national, lead and held locally in Arab countries. The second stage is rather at a Pan-Arabic level: wining applications are selected among those getting successfully the first round. The amount of the ALECSO Apps Awards is about 50 000 $US. The first edition (2015) of the competition was held in Doha, Qatar; and the second edition (2016) is going to be held in Dubai, UAE.
- ALECSO Apps training programs, aiming to introduce adults and youth people in the Arab region to the mobile technologies realm, and build and reinforce capacities in Mobile Apps development, ALECSO offers varied training programs ranging from short workshops to specific mobile development programs for a wide range of trainees from all the Arab countries. ALECSO Apps training programs provide trainees with continuous and consistent access to training, technology, and networks. The educational resources, material and activities used during training workshops and covering the required skills for the development of Mobile Apps are available online via the ALECSO online training platform[1]. So that discussions and interactions via the platform can continue after the official duration of workshops. Trainees are mainly teachers, students and developers from Arab countries. The ALECSO Apps training Programs are ensured basically via three modes:
    - Face to face training workshops;
    - Online learning, in the form of SPOCs and MOOCs;
    - Blended learning, in partnership with Academic and industrial partners in the region.

  A specific hybrid training programme (M-Developer) based on blended learning has just started in ALECSO when writing this paper. The pilot experience of this programme is being held with the partnership of the Tunisian Ministry of communication technologies and digital economy, and Tunisian universities, aiming to train 500 students enrolled in graduating class or newly graduated, on mobile apps development. The programme includes a training of Trainers workshop, a face-to-face phase, an online learning phase via dedicated SPOC (Small Private Online Course), and a coaching phase to define the Apps' ToRs and to

[1] http://training.alecso.org

develop and finally deliver and publish the Apps. As a second stage, ALECSO organization intend to duplicate this pilot project for Arab countries expressing an interest in disseminating and localizing mobile technologies. Moreover, an Arabic version of the MOOC on mobile development is under preparation and the first Arab based MOOC initiated by ALECSO is going to be launched next December.

3.2 ALECSO Cloud Computing Project

As for the cloud computing technology dimension, the ALECSO ICT department conducts a project aiming to improve the use of cloud computing technology in education and research in Arab countries. To this end, several activities are proposed in order to shed the light on the multiple benefits of this innovative technology in Arab educational institutions whenever well planned and deployed. It is in this perspective that ALECSO, jointly with ITU Arab regional office, endeavor to achieve the following objectives of the cloud computing project:

- Raising awareness on cloud computing technology and its benefits and advantages for the education field.
- Developing specific guidelines to ensure a cloud migration taking into account several parameters and national contexts for Arab countries.
- Delivering a cloud migration policy for decision makers.
- Defining and Implementing an Arab cloud computing pilot project for education and research.

3.3 ALECSO efforts towards promoting Open Learning

Open learning aims to provide learners with all the necessary requirements for success in a flexible lifelong education system centered on their needs, preferences, and objectives. Open Educational Resources can support largely Open Learning. According to the UNESCO description, Open Educational Resources (OER) provide a strategic opportunity to improve the quality of education as well as facilitate policy dialogue, knowledge sharing and capacity building [12]. In fact, the term of Open Educational Resources was coined at UNESCO's 2002 Forum on Open Courseware and designates «Teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions[2]». It was likewise formally adopted at the 2012 World OER Congress (Paris declaration), which marked a historic moment in the growing worldwide movement for promising Open Education. The number of institutions offering free or open courseware has been increasing since the organization of the OER first Forum. Besides, the most powerful asset of Open Educational Resources remain in its ability, when digitalized, to be easily accessed and shared online.

[2] http://www.unesco.org/education/news_en/080702_free_edu_ress.shtml

This refers to open licensed resources that can be legally used and re-used in an educational context. To this end, one of the best known legal framework, governing how OER are licensed for use, is the Creative Commons licensing framework. Indeed, the Creative Commons (CC) license[3], which has become widely used thanks to its flexibility to content authors and publishers, provides a set of sublicenses giving people the right to share, use, and even build upon a work they have created [13].

In the Arab world, there exist different level of awareness and master of using and developing OER, in the absence of an explicit vision or policy to empower and encourage such movement. Aside from some digital educational content repositories, mostly not open, existing through Arab virtual and/or classic universities, and schools, consortiums, and initiatives (Tunisia, Morocco, Egypt, GCC countries, etc.), there is a real lack in terms of OER development and use in Arab countries, especially in Arabic Language. In most cases, most of initiatives and projects are mostly issued from specific organization acting in the field of education such as UNESCO and OIF. However, those initiatives lack from sustainability and durability and after a number of years, projects generally fade away. As for regional projects and initiatives for the promotion of openness in education in Arab countries, we describe briefly in the following the Open Book initiative[4], and some of the ongoing ALECSO and UNESCO regional projects and activities.

The Open Book Initiative

In 2013, secretary Clinton Launched the Open Book Project, which is an initiative of the U.S. Department of State and the Arab League Educational, Cultural and Scientific Organization (ALECSO), leading education innovators to expand access to free, high quality open educational resources in Arabic, with a focus on textbooks in science and technology. It was considered that offering access to these resources will help to expand educational opportunities, further scientific learning and foster economic growth. The U.S. Department of state and ALECSO serve as the primary coordinators for activities on the project. In this perspective, an action plan representing main activities to be undertaken through the project was proposed. These activities covered mainly the aspects of capacity building, and the creation and dissemination of Arabic OER, and the expansion of the OER Community in the region.

Collaboration on Regional and International OER activities

Besides its participation and co-coordination of former projects aiming to promote OER in the region, namely the open book initiative, ALECSO has also joined the ongoing OER regional activities led by UNESCO. In this respect, ALECSO participated and/or co-organized recently several seminars and workshops, including:

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[3] http://creativecommons.org/

[4] http://iipdigital.usembassy.gov/st/english/article/2013/01/20130128141555.html#axzz2vr6NP51W

- The regional seminar on Open Educational Resources for GCC States and Yemen, held in Doha, Qatar - 18-19 March 2015, Organized by UNESCO and funded by William and Flora Hewlett Foundation.
- The UNESCO-ALECSO inception meeting on 'ICT-CFT: contextualization harnessing OER', held in Tunis, Tunisia, 17-18 August 2015.
- The OER National Meeting in Doha, Qatar October, 27th – 28th 2015.
- The international expert meeting, towards preparing the OIF action plan on OERs, held in Tunis 18 - 20 November 2015, and organized by the International Organization of Francophonie OIF, with the collaboration of the Virtual University of Tunis and participation of UNESCO and ALECSO Organizations.
- Open Educational Resources Road Map Meeting, held in Paris, 30-31 March 2016, and organized by UNESCO.

The ALECSO OER project :

The ALECSO OER project aims to promote the effective use of OERs in school education at Pan-Arabic level, which presents actually several benefits related primarily to OERs':

- Exchange: OERs can be exchanged widely across borders of the different Arab countries;
- Scope: OERs that are developed at Pan-Arabic level have a wider scope, since they are not driven only by local/national needs or requirements;
- Community: educational communities across borders of the different Arab countries can be created around OERs, which can lead to the exchange of good educational practices;
- Quality: OERs that are developed and promoted at Pan-Arabic level can increase their quality through extensive authentic use, reflections and modifications from communities of educational practitioners.

In order to reach these aforementioned benefits, three main milestones are defined within the project:

- Policies for OERs: to support different stakeholders (decision and policy makers, institution staffs, unions/teachers' associations, administrators/school leaders, teachers, students and parents) in Arab countries towards using and developing OERs at both national and Pan-Arabic level, ALECSO should draw from international OERs' best practices and from existing guidelines [14]. These guidelines must be contextualized and localized according to each country's status and specificities, and should include:
    - Best practices for sustainable development of OERs,
    - Ensuring quality while developing OERs,
    - Open licensing schemes during and after developing OERs,
    - Developing national OER repositories.
- Raise Awareness and capacity building on OERs: It is of the utmost importance to raise awareness, inform and train different stakeholders about the added value of OERs and their expected benefits in accessing and enhancing education.

- Technical Infrastructure: Promoting OERs at Pan-Arabic level means somehow offering a Pan-Arabian OER Infrastructure where teachers will be able to search and retrieve suitable OERs. The proposed infrastructure could be deployed nationally at different Arab counties (as national OER Portals) and then it could be integrated into a federated Pan-Arabian infrastructure promoting interoperability of these national OER portals.

ALECSO MOOCs' Project

The Massive Open Online Courses MOOCs concept, which emerged from open educational resources and e-learning, represents currently one of the newest and latest trend in the realm of online learning [15]. Two key distinctive dimensions characterizing those courses can be drawn obviously from the term MOOC itself: "Massiveness" and "Openness". Indeed, by providing MOOCs, it is intended to offer open learning for free to a wide range of online learners through the Internet, with the aim to gain new knowledge and skills in a specific major. This new trend of learning fits also into the international movement of openness whose benefits in education are endless since it ensures actually several opportunities to open up access to learning [16], not only for deprived communities but also in a wider context of lifelong learning meeting thus SDGs goals towards knowledge societies' end events [17]. Actually, one can find varied online content and courses available through known MOOCs providers and/or open educational repositories. However, such high level and mostly non-Arabic based online courses are neither available nor adapted to the specific needs of a large range of applicants in the Arab region, especially in education. To address such shortcoming, and given the interest in promoting and empowering the use and development of Open Educational Resources and Massive Open Online Courses, whether in the scope of formal or informal learning, ALECSO organization expressed a need to develop a capacity in this promising field throughout the Arab World. In this perspective, ALECSO organization prepared a scope study in order to lay down the scope of the different activities to be undertaken under the ALECSO MOOCs project whose general goals are as follows:

- Mastering by instructors from institutions within the ALECSO member states of the MOOC approach to online learning and the technologies to develop them.
- Offering a Pan-Arab set of tools to form a platform for Arabic-language MOOC courses development, hosting and referencing (and supporting obviously Multilanguage).
- Using the MOOC platform to develop prototype courses.
- Evaluating of the developed prototypes of MOOCs on a set of students from the ALECSO member states.

4 Conclusion

In the last recent years, education has witnessed great shifts, with the tremendous growth of ICT, in particular, the use of smart and mobile devices, which enable learners to learn more efficiently, flexibly, anywhere and anytime, at their own pace, to meet their objectives and requirements. Being aware of these major changes, and mindful of the current status of education and ICT readiness in Arab countries, the ALECSO organization proposed an entire framework embracing a set of key dimensions with the aim to prepare Arab countries in order to seize the new educational opportunities and to support and empower smart learning. In this respect, many projects and activities are being carried out. This paper provided an overview of the ongoing and planned activities undertaken so far by the ALECSO organization towards promoting smart learning in Arab countries, drawing from international practices, former experiences, and collaboration with partners.

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Learning to Analyze Medical Images: A Smart Adaptive Learning Environment for an Ill-Defined Domain

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Abstract. While Medical Imaging is a cornerstone of modern medicine, adequately instructing students in medical schools to analyze these images is still lacking in terms of allocated time and diversity in exposure. To help alleviate this problem we propose the creation of a new smart learning environment: the gamification of an online Intelligent Tutoring System focused on medical imaging. This proposed system makes use of modern serious games practices to increase student engagement, and plays on innovative student modeling techniques to provide learner adaptive feedback in a field of study where conventional techniques do not apply.

Keywords: Smart Learning Environments, Intelligent Tutoring Systems, Adaptive Feedback, Gamification, Medical Imaging, Serious Games, Reinforcement Learning

1 Introduction

Analysis of medical images is an important tool in modern medicine. Modern technology has changed how we explore and diagnose issues. Where once it would be necessary to preform a risky exploratory surgery to determine the source of an ailment, now an MRI can peer into the depths of the human body from outside. Beyond simply making diagnosis easier, modern technology has enabled remote diagnosis; an expert no longer needs to be present to provide insight.

These advances, though, come with a downside: the volume and variety of medical images produced has increased by leaps and bounds. With technologies such as Magnetic Resonance Imaging (MRI) becoming common place, the demand for professionals able to analyze them has increased. Unfortunately the current process of training such professionals follows an apprentice model with medical students following a fully practicing doctor in what is known as a practicum, during which they assist their instructor and review their cases. This has proven historically adequate but similarly, has some drawbacks. The students are only exposed to the cases that their instructor receives meaning that rare conditions are not seen, resulting in a less comprehensive education. In addition, the limited

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number of cases seen by a doctor means that the students have a limited ability to practice. Further worsening this is the difficulty of analyzing medical images, resulting in poor accuracy of detection[1].

A smart learning environment[2] could help with these issues in a variety of ways. By increasing the students' access to the cases including rare ones it can improve the breadth of their experience. To induce practice one can use techniques borrowed from serious games[3]. To retain the quality of instruction from tutoring[4] that a student receives during their practicum such an environment can use intelligent tutoring techniques.

To this end we have created a new online smart learning environment, a medical imaging intelligent tutoring system, Shufti. It uses gamification and social techniques to provide the learner with motivation to learn. To increase students access to cases it draws cases form large existing databases of medical images. To retain the benefits of tutoring it makes use of innovative student modelling to provide adaptive learner specific feedback in a domain of study which does not lend itself to normal techniques due to its structure.

Serious games, games which are used to teach serious topics, is an upcoming innovation in education[5, 6]. Gamification has many benefits such as being habit forming[7], resulting in more practice. Completion can transform routine tasks into interesting challenges. Social features can further improve the learning experience by allowing learners to share knowledge among each other. Our implementation is explored in Section3.1.

There are many large medical image databases online from which is it possible to draw exercises. Some examples are the Digital Database for Screening Mammography[8] or the Segmentation Chest Radiograph Database[9]. This enables students to see a broader set of cases than they normally would. These databases also contain rare cases as well, allowing students to increase the depth of the cases that they have seen by emphasizing rare or difficult cases. Our use of these is outlined in the introduction to Section 3.

With all of the above benefits, it is undesirable to lose the advantages of the practicum system, especially the benefits of one on one tutoring. To not lose these benefits modern intelligent tutoring system techniques can be used. Such a system can provide learner specific adaptive feedback to the students, simulating such a tutoring experience. In Shufti's case a innovative form of Reinforcement Learning[10] based student modelling is used to provide advice and feedback to the learner. This was done due to medical imaging being what is known as an ill-defined domain which is a domain which does not lend itself to normal intelligent tutoring system techniques. The motivation, challenges, methods, and validation of this are outlined in Section 4.

With all of these features combined, Shufti would provide a high quality education experience to medical imaging students, and is just about to be released to the public.

2 Contemporary Medical Imaging Learning

The analysis of medical images is an essential tool in the modern medical professional arsenal. Improvements in availability and technology has made them a common part of diagnosing many conditions. They are used by pathologists to analyze biopsies. Oncologists using magnetic resonance imaging (MRI) can see cancer long before it is apparent through other symptoms. X-Ray mammography is a key means for early detection of breast cancer. Dermatologist can detect melanoma using dermatoscopy or even normal photos of skin lesions.

Unfortunately the training of such skills is very difficult, one requires a significant number of cases to learn from to distinguish what are relevant features and anomalies in images. There is significant judgment involved and what is in an image is often unique or different from what a doctor has seen before. To remedy this, medical students follow or shadow an established specialist during what is called a practicum. This though effective, can result in a non comprehensive viewing of the possible conditions as the cases available for instruction are limited to the ones present during the practicum.

2.1 A Medical Imaging Smart Learning Environment

To resolve these problems, we have set out to create an online medical imaging smart learning environment. Such a tool has many desirable characteristics[11]. The system can contain many exercises featuring each possible condition, allowing for many hours of practice on even rarely encountered conditions. The system also provides adaptive feedback to the learner much as a real instructor would. The system also encourages the learners to continue to make use of it so as to help with maintaining familiarity.

Our medical imaging Intelligent Tutoring System initially focuses on the analysis of mammograms as there is significant demand for professionals with that skill. The system contains thousands of cases for the students to analyze. It incorporates new and innovative adaptive feedback selection techniques to simulate the presence of a human tutor. It makes use of gamification techniques to encourage more practice by the learners.

3 Shufti

Shufti[12] is an online ITS featuring gamification techniques and an adaptive feedback selection for learners. At the moment, it enables students to practice mammogram analysis on 1827 images revived from a variety of sources including the Digital Database for Screening Mammography[8]. Users are presented with a series of exercises of 4 different types depending on their *level*. These exercises take the following forms, in order of difficulty: Presence Exercises, in which the user is tasked with determining if there is a malignant lesion present in the mammogram displayed; Heat Grid Exercises, where an eight by eight grid is overlayed on the mammogram and the student receives information guiding them to the lesion, in the form of a simple hot and cold message; Gird Exercises which also have the eight by eight grid but lack the guidance; and Polygon Exercises, in which the learner is tasked to producing the exact outline of any lesions present in the mammogram. Figure 1 shows an example of a Heat Grid Exercise.

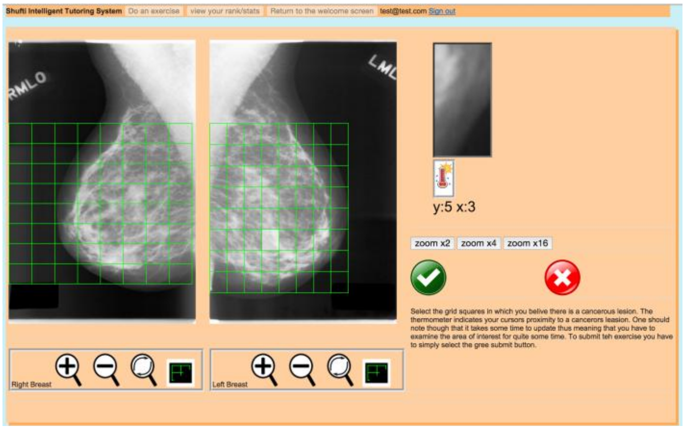

Fig. 1. The user interface for a Dual Image Heat Grid Exercise showing the hot-cold feedback, the zoom controls for the entire image and the zoom-lense for subsections.

3.1 Pedagogical Goals and Gamification

Shufti's Pedagogical goals are to improve the breadth and depth of the knowledge of medical imaging instruction. It is desirable for the learners to see and analyze as many cases as possible. It is also desirable for them to gain as much value out of each viewing as possible. To accomplish this Shufti makes use of modern gamification techniques, to have the learners view more cases than they normally would, while also causing them to focus on their own performance thus leading to deeper practice[6]. Gamification as described in Yee's Pedagogical Gamification[7] is a set of design principles used in the creation of a set of challenges, or in education's case exercises. These design principles are: Displaying Progress, Maximizing Competition, Careful Difficulty Calibration, Providing Diversions, and Employing Narrative Elements. We will now examine each of these principles and how it relates to Shufti's design.

Displaying Progress The display of progress to the learner is an important part of the game experience. By showing how far a player has come they receive encouragement and will continue to play. In the case of a serious game learners would continue to practice encouraged by their growing proficiency[13]. In Shufti displaying progress is accomplished through three means. First they have a prominently displayed score at the completion of an exercise, which is also tracked by a summary graph on the main page, enabling them to view their overall progress. Second as they improve their skills they can ascend to a new level where they are presented with more difficult exercises. Finally they have a chance of seeing the same exercise again, a fact that is revealed to them upon completion of the exercise, this is to enable them directly see their own progress.

Maximizing Competition Humans are naturally competitive, valuing the ability to compare oneself with peers. To succeed against others can be a powerful drive.

Shufti optionally provides learners with an anonymized ranking where they can compare themselves with their peers. It also allows learners to see how their peers answered exercises by overlaying colours on the mammogram indicating the frequency that areas were selected as containing malignant lesions (as a heat map), enabling a more focused comparison.

Careful Difficulty Calibration Challenge and the overcoming of challenges is an important part of game design. Too little challenge and the learner would feel the task is trivial and would not practice, too much challenge and the learner would grow tired or frustrated and give up. Shufti calibrates its challenge through the use of the previously mentioned levels.

Once they have demonstrated mastery of their current level they ascend to the next level, this continues until they reach the most difficult type of exercise. Each level also has limits on the subtlety and size of the lesion present. This in effect allows Shufti to adapt to the learner and their proficiency providing both a constant source of challenge and a display of the users progress.

Providing Diversions It is also important to break up the learning experience, to reset the learner's attention. This can be done though diversions not directly related to the core learning task. In Shufti's case there are many things that learners can do other than directly answering exercises. They have the ability to comment on the exercises they have seen and to see their peers comments. They can see replays of their mouse movements over past exercises to review their actions. They can also annotate the exercises so when they solve them again they can see their past opinions and considerations.

Narrative Elements Many games also provide narrative elements to further entice the learner. Unfortunately the analysis of medical images does not lend itself to this. However, it is not necessary for a game to have all of these principles to be engaging[7]. A good example of this is chess which is quite engaging but has no story at all.

By using the above principles and techniques Shufti provides an engaging learning experience that is adaptive to the individual learners skills

4 Smart Learner Adaptive Feedback

To properly simulate a tutor, an ITS must provide advice and encouragement to the learner. This is the foundation of the effectiveness of one-on-one human tutoring. Our proposed system makes use of a new innovative approach to issuing feedback in domains, where instead of trying to model the domain and infer what a correct action is, the system focuses on managing the learner's motivational state and overall correctness. This is done through issuing learner specific custom feedback. Effective feedback can produce large gains in the performance of individual learners[4].

Feedback is unrequested information given to the learner by the system. This differs from hints in that hints are user requested information. Feedback itself can have a polarity. Positive feedback is encouraging or reinforcing, for example "good job". Negative feedback is corrective or cautionary in nature, for example "You should look again". It is important to note that the polarity of feedback represents what the intended outcome is.

Unfortunately medical imaging is what is known as an ill-defined domain, which defeats most feedback selection techniques as they rely on having a model of the domain in which they instruct. A domain is a field of knowledge or study, such as mathematics or history. But not all fields have the same properties. Some, such as mathematics, are trivial for an automated system to reason about their structure. Others such as law, are not so easily reasoned about. The latter type of domains are called ill-defined while the former type are called well defined.

4.1 Well-defined Domains

A domain is classified as well-defined if it has all of the following attributes: verifiability, formal theories, a well-defined task structure, clearly defined concepts, and a decomposable task structure[14]. These attributes also enable the use of conventional intelligent tutoring techniques and domain modelling.

Verifiability A well-defined domain must have verifiable answers - such as in arithmetic where there is only one correct answer for a given problem - or, at the very least, the ability to distinguish a correct answer from an incorrect answer. Problems in ill-defined domains lack verifiability in that they commonly do not have a truly correct answer. For example, consider a writing exercise in which the goal is to write an interesting story. It is possible to write an interesting story and it is possible for one to manually determine if a story is interesting, but there is no one correct answer to the exercise. In other words, an ambiguous notion of correctness is one of the possible features of an ill-defined domain, which is in conflict with the idea of verifiability.

Formal Theories A well-defined domain must have a clear-cut set of rules, or formal theorems within which one can reason and solve problems. An example of the use of formal theorems is symbolic logic in which the entire problem space is well-defined and there are rules which can be applied in all situations. In contrast, in image medical diagnosis, there are only vague notions of formal theories. This vagueness and lack of theories exacerbate the creation of domain models which results in ill-defined domains.

Well-Defined Task Structure A well-defined domain must have a regular task structure or, as stated in Fournier-Viger et al. [14], be a "Problem Solving Domain". Task structures other than problem solving are possible, but they are ill-defined. An example of this is an analytic task which requires the learner to make choices based on incomplete or erroneous information and in effect "use their judgment". Another example is a problem in which the desired outcome is pre-defined and where novelty is desired such as in writing.

Clearly defined concepts For a domain to be well-defined, its concepts must have a clear definition, without ambiguity. For example, a triangle is a well-defined concept with no ambiguity. This is not always present within a domain. For example, the various styles of art are not well-defined and a work's inclusion in a particular style is based more on consensus of the community and the statements of the artist than on any hard definition. However, clear, unambiguous definitions are necessary if one is to reason about concepts within a domain.

Decomposable task structure For a domain to be well-defined it must be possible to decompose problems within it to a sequence of independent steps. For example, when solving a logic problem the correctness of a given step can be determined from the current state and the desired end state. The correctness of steps taken before the current step have no influence on whether the current choice is correct.

4.2 Medical Imaging as an Ill-Defined Domain

Medical Imaging is an ill-defined domain as it lacks some of the attributes of a well defined domain as is argued by Crowley and Medvedeva[15]. It lacks formal theories as it relies on the judgment of the person preforming the analysis. It also does not have clearly defined concepts, for example the line between a cancerous melanoma and a benign one is not clear. However it does have some properties which make it possible using unconventional methods to create an ITS without a model of its domain. The domain is verifiable, the task structure is well defined, and the problem is comprised of discreet sub problems. The domain retains verifiability as with human annotation it is possible to create a gold standard of correct answers to medical imaging problems. The task structure is well defined as the task is simply to determine what the correct diagnosis should be. Also the problem is established independent of sub tasks, such as each exercise is self contained.

4.3 Methods

Adapting feedback to individual learners is a non trivial task. Learners vary significantly in their preferences for what kind of feedback they receive and the amount. Further complicating this is that as a learner's proficiency improves the most effective feedback strategy can shift as shown in Soldato et al. [16]. In which while initially acquiring skills, learners liked many positive reinforcing feedback but once they were more proficient they preferred more negative corrective feedback to point out their remaining misconceptions.

There are many possible tactics with which to provide adaptive feedback, for example in a well defined domain such as mathematics, an ITS can simply indicate the error that the student made by comparing their actions with the steps taken by a computer algebra system. In the case of ill-defined domains, unconventional techniques are required as in Perelman et al.'s Code Hunt[17], a programming ITS, in which how prior students resolved errors is used as the basis for corrective feedback for students.

We propose a new method of providing learner specific adaptive feedback, which is in use in Shufti. This new method makes use of reinforcement learning algorithms[10] to model students to allow the system to determine the most effective feedback strategy for the learner, even in the case that no feedback at all is the best choice. It is described in more detail in Custom Feedback Selection for Intelligent Tutoring Systems in Ill-Defined Domains [18].

Reinforcement Learning is a branch of artificial intelligence which learns how to solve non stationary problems in a real time manner. It learns and adapts to the problem even as the problem changes. These attributes are important as learners feedback needs can shift over time and the system must be able to react to changes and novel situations. The high level explanation of Reinforcement Learning is thus: given an environment which provides a reward signal and a state signal, control an agent/actor within that environment such that over time the reward signal is maximized.

To characterize providing feedback to the learner in such an environment, we did the following. The current score, as though the learner had submitted the exercise, is computed. It is then discretized into a state signal with 3 possible values and is used as a state signal for the Reinforcement Learning agent. The discretized score is placed in the ranges of greater that 0.5, less than 0.5 but greater than 0.25 and less than 0.25. These ranges were chosen to efficiently represent the difficulty of the mammogram diagnosis and to make the learning rate of the agent as rapid as possible. The reward signal of the agent is again the learner's score but it is not discretized. This reward signal was chosen such that the system would learn the most effective feedbacks as quickly as possible by observing its feedbacks effects during exercises.

The agent chooses from a list of possible feedbacks to issue to the learner. The list is a set of General Statements and, advice for the learner, labeled with a polarity, either positive or negative. Positive feedbacks are reinforcing in nature, advising the learner to continue with their current course of action. Negative feedbacks are correcting in nature, and attempt to dissuade an incorrect course of action.

The Reinforcement Learning agent is limited to positive feedbacks if the learner has been improving their answer and is restricted to negative feedback when the learner has made the exercise state worse.

The division between negative and positive feedback is important as it prevents the agent from issuing feedback which does not match the current situation for example, issuing encouraging, positive, feedback when the learner has made a mistake. At all times it is possible for the reinforcement learning agent to choose to issue no feedback and, in fact, that is a common choice.

Each learner has their own agent which, over time, learns their preferences for feedback, which ones are effective in improving their performance and which ones make the learner act incorrectly. This results in the system eventually issuing only the feedbacks the learner likes and which are effective in helping them learn.

4.4 In Vitro evaluation of feedback system

To provide some validation of the effectiveness of this feedback system we have created a learner simulator. This is to provide us with some idea as to its effectiveness and to provide a form of theoretical validation as argued for in Self's Theoretical Foundations for Intelligent Tutoring Systems[19]. At a high level a set of simulated learners are tasked with answering exercises within Shufti. These simulated learners produce realistic answers to the exercises and over a simulated course slowly improve. Each learner also has preferences related to feedback, represented by a given feedback improving or worsening their performance. Each learner’s preferences for feedback are unique.

To use this as validation we then compared runs with feedback being possible to ones where it was not and we saw some significant gains in the simulated learners performance. With simulated learners without feedback achieving a course average of approximately 60% and ones with feedback achieving 77%.

With the validation in hand it is our hope that this system when placed online will become a useful tool for teaching the analysis of mammograms.

5 Conclusion

Medical Imaging is a large and growing field with significant utility. Unfortunately it is also difficult to train students in. The variety and difficulty of the cases results in a less satisfactory outcome. Shufti, our ITS for medical imaging, uses gamification of learning, an extremely large exercise set, and adaptive feedback to remedy this. Applying reinforcement learning to adapt Shufti and personalize feedback was shown effective based on simulated evaluations.

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An Architecture for Smart Lifelong Learning Design

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Abstract. Smart learning environments have emerged as powerful platforms that support learners in exploring, identifying and seizing not only formal but also non-formal and informal learning opportunities, enabling them to create rich learning experiences. This paper introduces a lifelong learning framework underpinned by the idea of a cumulative learning continuum from pedagogy through andragogy to heutagogy. Based on this framework, we propose a system architecture that aims to provide personalized lifelong learning pathways integrating formal, non-formal and informal training offerings. This could further motivate learners to engage in meaningful learning experiences throughout their lives.

Keywords: personalized learning · lifelong learning · learning path design

1 Introduction

Lifelong learning continues throughout our lives beyond formal education [11], and, therefore, it cannot be associated with any specific age group or learning setting (formal, non-formal, or informal) [15].

This paper describes a theoretical framework for lifelong learning and presents a Smart Learning Environment (SLE) architecture to facilitate learning across different earning contexts. This is based on a layered framework that can link formal, non-formal and informal learning experiences and can serve as a bridge between existing learning models in a cumulative continuum from Pedagogy through Andragogy to Heutagogy. This attempt represents a modest step towards learner autonomy, which, however, can potentially motivate lifelong learners to engage in learning activities and achieve their learning goals.

The rest of the paper is organized as follows. In Section 2, the theoretical framework underpinning this work is described. Section 3 provides an overview of the overall SLE architecture, while Section 4 provides concluding remarks and discusses future work.

2 Theoretical framework

In this section, we set out a theoretical framework for smart lifelong learning design.

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Instructional methodologies for developing lifelong learning skills are mostly based on constructivist theories and aim to create educational opportunities to develop learners' capacity for self-direction, metacognitive awareness, and a disposition towards lifelong learning [5].

Self-direction implies that the learning process is internally and psychologically controlled by the learner. This translates in learners diagnosing their needs and formulating their learning goals, choosing the learning resources, designing appropriate learning strategies and evaluating learning outcomes. Moreover, learners can take advantage of the collaboration with peers and colleagues, teams, informal social networks and communities of practice [14].

Metacognitive awareness is the learners' awareness of their own cognitive processes. Such skills are required in order for the learners to select learning behaviors and strategies, and to monitor and evaluate their effectiveness through self-assessment and reflection.

Disposition towards lifelong learning can be translated in regarding learning as an ongoing process that requires learners to be intrinsic motivated, persistent, willing to take risks and learn from their mistakes, and having the intellectual curiosity and desire to build on existing knowledge.

Team-based approaches (communities of practice, communities of interest) and knowledge sharing in the form of sharing resources and information are recommended practice of the heutagogical approach that has collaborative learning as one of its critical components [1], [3], [8], [9] . The pedagogical aspect of the model is underpinned by the idea of the Pedagogy – Andragogy – Heutagogy (PAH) continuum [7]. Learners typically start from pedagogy and progress through andragogy to heutagogy as they progress in maturity and autonomy [4]. This progress can be regarded as learners gradually developing the three fundamental lifelong learning characteristics of self-direction, meta-cognitive awareness and disposition towards lifelong learning. This progression can be scaffolded by appropriate learning design tools controlled by tutors or experts and partially by the learners. Shift of tool control from tutors/experts to learners could indicate an increase in learners' maturity, and thus their readiness to undertake control of their own learning. Tutors'/experts' role with respect to learning design tools would then change from that of knowledge facilitators to learning strategy validators. It can be claimed, therefore, that heutagogy enables learners to determine their learning path when supported by a Web 2.0 technological framework, and social media can support important elements of the heutagogical approach like group collaboration and reflective practice through double-loop learning [3].

In order to enable learning across the PAH continuum, a set of tools is needed to support meta-learning, reflection, problem-solving and instructional scaffolding. Developing a capacity for self-direction, metacognitive awareness, and disposition towards lifelong learning is facilitated by specific instructional features, i.e. autonomy, intrinsic motivation, enculturation, discourse and collaboration, and reflection [5]. **Table 1** associates these features with learning processes**,** and then maps them to SLE requirements.

Table 1. Learning considerations of the PAH continuum and implications for tools design

Learning process	Requirements for Smart learning environments tools
Meta-learning	Enable learner autonomy, learner-designed learning
Reflection	Enable collaboration, support learners in planning and selecting learning strategies, support for self-assessment and review, personal learner blogs
Problem-solving	Support learners in identifying, finding, using and critiquing resources
Instructional scaffolding	Foster the development of social skills, provision of coaching through student participation in communities of interest/practice
Intrinsic motivation	Motivation to engage is evoked by the novelty of web 2.0 technologies, learner autonomy

3 Smart learning environment

Fig. 1. illustrates the key components of the SLE: a Learning Management System (LMS), an e-Portfolio tool, a Web-based Intelligent Educational System [10], social media (e.g. forum, wiki, blog, etc.), formal and informal educational resources and a learning design tool. Components communicate and exchange information through an Enterprise Service Bus (ESB). At this point, we will not consider the way users access services and the context-awareness (context model of physical situation) in our environment. The smart learning service in this case consists in the information exchange among various learning systems, platforms, tools, and resources in order to provide an enhanced personalized learning experience to the user.

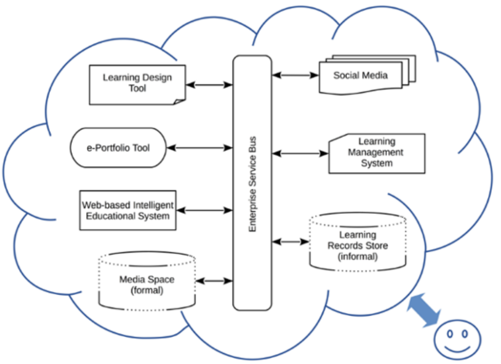

Fig. 1. A smart learning environment implemented as services in the cloud.

The SLE modules listed in the first column of **Table 2** fulfill the essential criteria to implement a SLE [12]. The functionality of each of these modules is distributed among the cloud services listed in the right column of **Table 2**. The selection of the specific services was based on the requirements of **Table 1**. In addition, a set of databases listed in the left column of **Table 2**, marked by DB, is used to provide the data needed by the SLE modules. The second column of this table lists the corresponding cloud services that store those data in a cloud SLE. In the remaining of this section, each of the SLE parts will be reviewed starting with the ESB.

Table 2. SLE modules and databases, and corresponding cloud services or cloud data storage

SLE modules (M) and databases (DB)	**Smart learning environments cloud services/data storage**
Learning status detecting module (M)	e-portfolio tool, web-based intelligent educational system, learning management system, social media
Learning performance evaluation module (M)	Learning design tool, e-portfolio tool, web-based intelligent educational system
Adaptive learning task module (M)	Learning design tool, learning management system, web-based intelligent educational system
Adaptive learning content module (M)	Media space, learning resource store, learning management system, web-based intelligent educational system
Personal learning support module (M)	Learning design tool, learning management system, web-based intelligent educational system, e-portfolio tool
Inference engine (M)	Learning design tool, e-portfolio tool
Learning portfolios (DB)	e-Portfolio tool data storage
Test bank (DB)	Learning management system, web-based intelligent educational system, media space, learning records store
Learner sheets and materials (DB)	Learning management system, web-based intelligent educational system, social media, media space, learning resource store
Learning tools (DB)	Learning management system, web-based intelligent educational system, learning design tool, social media
Learner profiles (DB)	Learning design tool, e-portfolio tool, web-based intelligent educational system tool, learning management system, social media
Knowledge base (DB)	Media space, learning resource store, learning design tool

Enterprise Service Bus. All services in **Fig. 1.** communicate through the ESB, a mean for integrating heterogeneous applications seamlessly [13]. The ESB can be used to exchange information related to user models, formal and informal educational resources and their metadata, domain models, learning paths, and service availability. A common ESB should provide the following fundamental features:

- A routing mechanism that enables efficient and flexible services communication.
- A mechanism for transforming the information format of the requester service to the information format of the responder service.
- Extensibility through multiprotocol transport support that can cover all the applications' needs for exchanging information.
- Security in the form of authentication and authorization when accessing services.

Information exchange among SLE services through the ESB takes place in seven steps:

- Requesting service sends request to the ESB
- ESB authenticates and authorizes the request
- ESB transforms request to the destination service's information format
- Destination service receives request from ESB and sends reply to the ESB
- ESB authenticates and authorizes the reply
- ESB transforms reply to the requesting service's information format
- Requesting service receives reply from ESB

Learning Management System. LMSs have the advantage of being easily extendable and can aggregate the functionality of e-portfolios, social media, educational resources and learning design tool in the form of plug-ins. However, in this paper it is assumed that such plug-ins are not installed in the LMS. The LMS of **Fig. 1.** can access educational resources stored in the Media Space and the Learning Records Store, and exchange user model data with the rest of the SLE services.

E-Portfolio tool. Contains information about learner competences and/or skills and is usually used for personal development planning. Such tools can benefit from the exchange of user profile data with other services of the SLE, e.g. the LMS, Social Media, Web-based Intelligent Educational System and Learning Design tool.

Social Media. Different types of Social Media that foster collaborative learning, both formal and informal (e.g. communities of practice/interest), can be grouped in this service type. Information that can be exchanged with the other SLE services includes user profile data and user-generated content.

Learning Records Store (LRS). Contains informal educational resources in the form of Informal Learning Objects (ILOs) and Informal Learning Activities (ILAs), which can originate either from user-generated content or from an Informal Learning Portfolio Service [6], which is an e-Portfolio service in the SLE. LRS provides the learning resources and metadata needed by other SLE services.

Media Space. Formal educational resources are usually stored in a media space, along with their description models. SLE services can search for appropriate learning content by requesting metadata from the media space service.

Web-based Intelligent Educational System. This system uses artificial intelligence methods and analytics. In order to provide an enhanced learning experience to the lifelong learner, this system would need to exchange user model information and educational resource metadata with the other SLE services.

Learning Design tool. This study considers learning design tool as a broad category that includes different abstraction levels of learning design, from single activities and learning objects to whole courses, curricula and learning paths. As part of a SLE, a tool for learning design can benefit from the exchange of user model information, in order to provide a better learning experience. Having a more complete and precise user model, the tool can help the designer to accurately select the appropriate learning methods and link them to the available educational resources.

Technologies and standards that can be used to implement the above framework include the Experience API (xAPI) for accessing educational resource stores, the Lifelong Learner Ontology [2], the IMS Learner Information Package and the Resource Description Framework (RDF) for the user model, and the IMS Simple Sequencing for creating the learning paths. Standard web-service technologies can enable the access and exchange of user model information, like e.g. the Universal Description Discovery and Integration protocol (UDDI), the Web Services Description Language (WSDL) and the Simple Object Access Protocol (SOAP).

4 Conclusion and future work

Lifelong learners need support in selecting appropriate learning experiences from a plethora of available educational resources. In this paper, we described the architecture for a SLE, where various services communicate through an enterprise service bus, to support personalized lifelong learning. This is based on a theoretical framework that builds on the PAH cumulative continuum to link formal, non-formal and informal learning experiences. Future work will concentrate on examining possible ways to implement and evaluate the proposed framework.

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Relevant Metrics for Facial expression recognition in Intelligent Tutoring System

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Abstract. This paper concentrates on testing Facial Expression Recognition metrics such as anger, contempt, disgust, happiness, neutral, sadness, and surprise to determine which of them is the most appropriate to provide effective feedback in an Intelligent Tutoring System. We discuss how to exploit this tool to develop an intelligent system to deep the students' understanding of basic scientific principles and concepts during the learning process, in order to improve the teaching in distance education. In fact, despite of the growth of E-learning environments, it's already difficult to detect the student's emotions and attention so we look up in this paper the relevant metrics with a best accuracy for generating the proper feedback in response to the student's expression during experimental learning sessions.

Keywords: Relevant Metrics; Facial Expression Recognition; video sequences; image; Intelligent Tutoring System

1 Introduction

Human face is considered as the most efficient way to know a person's behavior, personality and cognitive state [1]. In fact, several Emotion Recognition System have spread is in a wide range of fields like entertainment, economic activities, security, and especially education. Nowadays, Emotion recognition represent an important component in artificial systems that can understand and identify human's emotions from expressions on a person's face which is performed in real time starting from an image or a video stream.

This paper describes the methodology applied on video recordings of facial expressions student volunteers while realization an experimental learning process in Remote Laboratory (RL) [2] due to the input sensing device that is webcam which is previously validated research in [3]. Our target consists to recognize student's expression that is extremely useful for us to build an accurate Intelligent Tutoring System (ITS) [3]. We choose to deploy a facial expression recognition system in E-learning context [2]. For this purpose, we adopt Microsoft's Project Oxford which based on its machine learning Face detection API and Artificial Intelligence (AI) research . Where input is taken from image to recognize such eight human feelings

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from expressions on a student's face. The current work aims to interpret different video sequences by observing the student's face setting through the same time that every learner does their practical work in RL who need no doubt help when he encounter difficulties. The first statistical results helped to highlight the need of student's assistance in some questions of the content of practical work. Moreover, that gives us the opportunity to find the most relevant metrics of Facial expression for the application of ITS more particularly in remote laboratory. Especially that according to the analysis of Related Works it's not yet known what metric of Facial Expression Recognition is important in this area.

The rest of the paper is organized as follows: in Section 2 we report the adopted methodology so far which includes a system graph in order to facilitate the presentation of our approach. In Section 3 we provide principles aspects of Artificial Intelligence. In Section 4 we explain results from the application of our methodology and in Section 5 we list our conclusion and a brief discussion of future work and prospects.

2 Methodology

In this section, we review the overall architecture of our approach which we use throughout the research as shown above the following steps which summarize our work in (Fig. 1). In the RL, the student begins his reserved practical work session, at this time, the webcam is starting and the video is recording. After collect recording video we proceed by cropping each video in image sequence [4] which is considered the easiest way to delimit only the student's face. Then using an algorithm to enter images successively in the API which one uploads then detects face using the core 7 emotions , and Neutral thanks to the function `UploadAndDetectEmotion()`.
The Microsoft's Project Oxford outputs is exploited after the algorithm detects emotions present in a face from a photo then, it responds in JSON with specific percentages for each face. All emotion scores in API are normalized; we can to sum to one. We consider the emotion that have highest score depending on our needs. Finally, we collect output results of all student face their interpretation will help us to build an Intelligent Tutoring System [3].

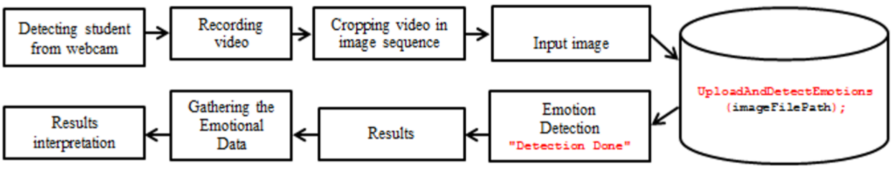

Fig. 1. Graphical outline of our approach

3 Experimental results

The tests of experience are collected during the 2014-2015 academic year. Students (N=27) interacted through a platform that provided remote learning tasks [5]. The

participants were university students in National School of Engineers of Sousse Tunisia, with average age of 22 years. The students voluntarily participated for remote laboratory in higher education sector of Electrical Engineering.
Our approach is listed as follows: First, we consider the difficulties mentioned through the survey questionnaire. Secondly, we visualize the video manually and note frustration time of student. Thirdly, we validate this moment with the content of the questionnaire. Fourth, we collect emotional data extracted via the API then we neglect the neutral emotion in the same time previously indicated. And fifthly, we compare emotions manually with other students. The presented results in (Fig. 2) at right show that are quite sufficient to identify the difficulties encountered by six students in the same experimental learning session of electronics called "Static TP" in RL according to the temporal evolution of the emotion state varies over frames like example at Table 1 which report the highest score [6]. The same result is obtained from the experiments in (Fig. 3) at left, the difference is that is not the same practical work, this one is called "Dynamic TP" using also the same proposed approach.

Table 1. The obtained Emotion recognition results(%) of facial expressions for the "Static TP"

Facial Expressions		Students: Hajer	Hosni	Oussama	Karima	Ines	Mariem
Anger	1	0	0,01	0,01	0	0,01	0,01
Contempt	2	0,08	0,03	0,02	0	0,08	0,31
Disgust	3	0,02	0,02	0,00	0	0,05	0,23
Fear	4	2,46	0,01	0,04	0	4,03	2,62
Happiness	5	3,12	0,01	0,00	0,01	0,01	0,03
Neutral	6	49,84	72,25	95,56	96,99	57,17	51,37
Sadness	7	18,85	0,07	0,15	1,02	8,64	0,99
Surprise	8	**25,63**	**27,61**	**4,21**	**1,95**	**30,01**	**44,44**
Accuracy		100	100	100	100	100	100

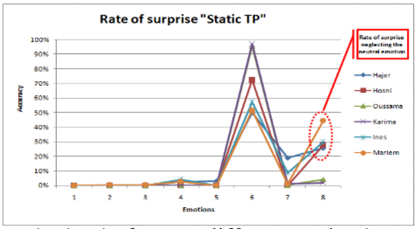

Fig. 2. Facial expression recognition performance obtained of seven different student's face for the "Static TP"

Table 2. The obtained Emotion recognition results(%) of facial expressions for the "Dynamic TP"

Facial Expressions		Students: Wassef	Zeineb	Faten	Khira	Lyna	Marwa
Anger	1	0	0,09	0	0	0	0,01
Contempt	2	0,13	0,09	0,02	0,22	0,02	0,07
Disgust	3	0,01	0,26	0	0	0	0,01
Fear	4	0,00	18,73	0,14	1,63	0,37	0,24
Happiness	5	0,04	0,52	0	0	0	0
Neutral	6	99,36	46,02	99,17	54,94	67,99	59,35
Sadness	7	0,05	14,55	0,21	0,06	0,09	1,11
Surprise	8	**0,40**	**19,74**	**0,45**	**43,15**	**31,53**	**39,20**
Accuracy		100	100	100	100	100	100

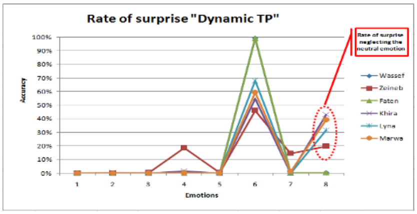

Fig. 3. Facial expression recognition performance obtained of seven different student's face for the "Dynamic TP"

In addition, the rate of the metric Surprise shows the same difficult question for ach TP in the remote work which reveled in the questionnaire. In interpreting results from figures bellow, we can see from the tables also that all emotions expect Surprise and Neutral, their accuracy rate is relatively very low, in consequence it is not important to report all of these metrics because which are considered neglected emotions so it is not especially significant. While the emotion "Surprise" have the highest accuracy rate for all students tested. It's considered as the most relevant metric among the other emotion's metrics.

4 Conclusion

In this paper, we exhibit a thorough experimental investigation of apply the API focused around facial expression recognition in order to achieve the desired educational objectives. The important merit of this work is that can be able to assure interaction between student and the Intelligent Tutoring System due to these experimental results. The next step of our project is the integration of this experimental investigation in our model of ITS. We aim to generalize the results and will be achieved definitely by doing more tests in new faces because ITS must able to adapt over time. However, we focus in relevant emotion's learner related to E-learning context in remote labs which indicate that this emotion represent situations of frustration and not another. The project will have a revolutionary impact in the engineering education to increase the effectiveness of LR because it's till now relatively unexplored [7].

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Toward an Adaptive Architecture for Integrating Mobile Affective Computing to Intelligent Learning Environments

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Abstract. With the advent of mobile technology, Wireless Sensor Networks as well as Smart wearable devices, relevant Mobile Affective based learning systems could be developed. This enables not only to recognize users' spontaneous affect state but also to react appropriately to that state. However, additional complex requirements are arising such as handling affect data heterogeneity as well as continuous and unpredictable dynamic changes of the sensing capabilities. The present work aims therefore to overcome these requirements by providing flexible and adaptive software architecture based on semantic models.

Keywords: Affective Intelligent Learning Systems · Adaptive software architecture · Mobile Affective Computing · Semantic affective models.

1 Introduction

Currently, several categories of Intelligent Learning Environments (ILE) such as Intelligent Learning Management Systems (ILMSs) or Tutoring Systems (ITSs) are more and more available. With the advent of Affective Computing (AC) technology, systems are increasingly integrating explicitly features for processing users' emotional and affective states. Video games were first to integrate those features followed by ITSs [12]. However, LMSs have not yet integrated those aspects. Moreover, the AC domain is continuously evolving especially with the emergence of mobile computing, Wireless Sensor Networks and wearable computing. Smart phones are also increasingly enriched with sensing features. Combining Smart mobile wearable devices (e.g. Glasses, Watches), sensors and AC offers new research opportunities and creates what is called Mobile AC [15].
The main question that is raised in the present research work is the following:
What kind of software architecture is it possible to use in order to take into account ILE's and MAC's advantages and build a single flexible and adaptive Mobile Affect ILE?
In order to answer the raised question, the rest of the paper is structured as follows. In section 2 related works are presented, and classified. The section 3 presents fundamental aspects of the proposal. It describes (1) specific requirements and motivating orientations, (2) the process that relates affective

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states acquisition and analysis to learning decision making, (3) fundamental models on which relies the process. The section 4 presents the proposed software architecture while the section 5 presents a prototype implementing the solution. The experimentation of the prototype is also realized through simulation of affect states acquisition and a concrete example using a MAC headset detecting meditation and attention related to Electroencephalograph (EEG) signals. Finally, a conclusion allows positioning the current state of the research and discusses insights and future orientations.

2 Related work

Three categories of related work are identified in the literature. The first category attempts to provide approaches, models and methodologies for enhancing affective states recognition and analysis. The second category focuses on the reactive behavior of the system after analysis while the third category focuses on the ability of the system to overcome heterogeneity and dynamicity of new categories of sensing devices and their requirements.

Most affective ITSs are part of the two first categories [1], [14], [8] and [4] while work in [9] may be classified into the second and third categories. Indeed the authors have provided an affective e-Learning model that uses physiological signals to sense emotion evolution and to provide adapted learning content to remote learners in distributed Smart classrooms. This work relies on an existing pervasive e-Learning platform. Issues addressed in the SM4ALL project[1] are not intended to e-Learning domain, they are however about architectural problems related to heterogeneous devices discovery. The aim is to build a new middleware platform for inter-working of smart embedded devices in the home automation scenarios [13].

As a conclusion of this section, even though several ITSs have integrated affect analysis, adaptive reactivity and remediation to negative affective states, these aspects have not been yet extended and used within ILEs. Additionally integrating MAC into ILEs and using relevant adaptation/reconfiguration mechanisms to take into account MAC devices changes have not yet been addressed especially by making use of auto-reconfigurable software infrastructures, flexible architectures and sound semantic models.

3 Proposal description

3.1 Specific requirements and motivating orientations

Existent systems present issues regarding (1) their flexibility and maintainability when additional features are needed and (2) their capability to communicate and

[1] http://www.sm4allproject.eu

interact dynamically with new affect sensors. These issues are about the system's architecture and enabling software infrastructure. They could be addressed by (1) granting modularity and fine granularity of the system's components (2) making use of dynamic adaptable software infrastructures such as those based on OSGi technology, (3) making use of technologies enabling dynamic discovery, orchestration and execution of software components or services that are necessary either for augmenting the system with additional features or new sensing capabilities.

Such technologies are for instance promoted respectively by Semantic Services Oriented Architectures (SSOA) and Semantic Sensor Networks (SSN) [10] and [3] which enable the system to discover, select and execute software and sensors' services in order to achieve a given goal. For instance authors in [7], [6], have designed and developed an ILE based on SSOA and OSGi technology. While authors in [11] have used semantic models to integrate learning standards such as SCORM[2], LOM and IMS LD[3] with those of Internet of Things to enable learners' track within learning environments (virtual and physical).

The challenging issue leveraged therefore by the present work and which constitutes its main contribution is to integrate MAC features to those of ILEs and hence to propose a unified conceptualization of the future Semantic Web and OSGi based Mobile Affect ILE by focusing on (1) the process that discovers new sensing devices, captures and manages affective states and adapts dynamically the ILE behavior by considering pedagogical rules and (2) the design of relevant semantic models for affective states, sensing and learning services (3) the description of the flexible and adaptive architecture that enables the enactment and execution of that process.

3.2 Description of the Affect-Learning Process

The Affect-Learning Process is a continuous loop composed by the following sub-processes and tasks.

3.2.1. Affect acquisition sub-process

The acquisition sub-process relies on sensors warn by the learner and interacting with the system to transfer observed states. In MAC systems, sensors' services are dynamic and may interact with the target system via different connectivity and communication protocols such as UPnP, Bluetooth Low Energy or other proprietary protocols. In this context, the Semantic Sensor Web, where ontologies (.e.g. SSN Ontology) have been proposed as key enabling technologies for sensor networks because they can improve semantic interoperability and integration, as well as facilitate reasoning [3]. Therefore for the specific needs of the target system, the SSN ontology is extended with an additional module as illustrated in

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[2]http://www.adlnet.gov/capabilities/scorm.htm
[3] http://www.imsglobal.org/learningdesign/

Figure 1 where the sensor and the Natural persona concepts are extended respectively with the Affect Sensing Device taxonomy and other sensing means such as the instructor, the pedagogical Model, etc. Once a new affect device is paired with the system, its services and corresponding sensing capabilities are advertised and stored within the SSN extended module.

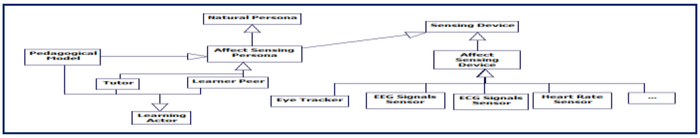


Fig.1. The SSN ontology Extensions

3.2.2. Affect analysis sub-process

The affect analysis sub-process receives raw data from the acquisition sub-process and translates it into human and/or machine comprehensive affective states [5], [2]. In the context of the present work, an Emotions' model is defined as an extension of the xAPI model and expressed semantically by an ontology called XEmotionsOnto (eXperience Emotions Ontology illustrated in Figure 2).

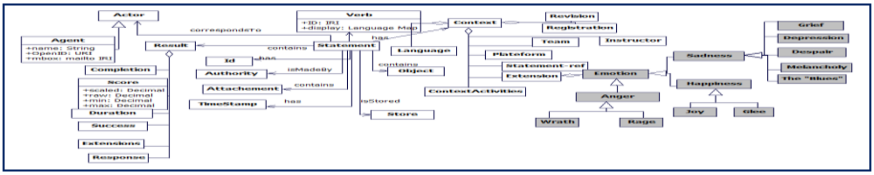


Fig.2. The xEMotionsOnto Model

3.2.3. Decision making sub-processes

Given an emotive state, tow kinds of decisions could be handled by the system, the first one concerns the reconfiguration of the system architecture by replacing and/or updating software components as described in [7]. The second one is related to learning processes adaptation in order to reinforce motivation and overcome negative affective states. An example of adaptation is to provide a game based or a collaborative replacement activity for the current non game based or individual activity.

4. The adaptive software architecture

The affect ILE being developed is Web oriented. The underlying infrastructure being used is an OSGi based run-time environment providing all required features to expose and execute software components as Restful Web services. It is dynamic in such a way that updated components or new added ones are automatically picked up by the run-time and rendered active. Semantics have been added to OSGi by re-using third party OSGi bundles as Jena based OSGi Bundle for making use of ontologies and reasoning capabilities. The architecture software of the system is decomposed into several technical layers granting thus the separation of concerns of the system's components (Figure 3).

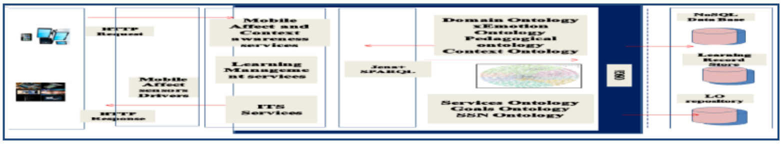


Fig.3. The Mobile and Affect ILE Architecture

5. Prototype implementation and validation

In order to validate the architecture, a use case simulating the system has been realized. The Figure 4 shows a simulated heart rate sensor using UPnP protocols and which is discovered by the device tester (also simulating an UPnP control point).

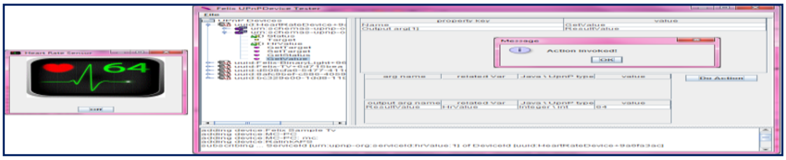
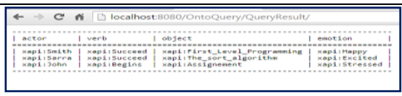


Fig.4. The heart rate simulated sensor

In Figure 5 (a), after sensors have been discovered and their description stored into the extended SSN ontology, the Querying Restful Web service shows the affect sensors available in the Network and their respective capabilities. The Figure 5(b) shows the emotive sates and xAPI statement about the learner.

(a)



(b)

Fig.5. (a), (b) The system's discovery and answers to affective states

6. Conclusions and future works

The present paper highlighted firstly, the benefits of integrating MAC features into ILEs and secondly the fundamental problems and requirements that are faced during that integration. Main contributions of the paper are the conceptual model of the Affect ILE, its underlying process, its software architecture and the semantic models provided to take into account new MA devices discovery, interactions and users' affective states and context changes. Main aims in the future are (1) to extend the affect ILE with gamification features; (2) to consider empirical and analysis methodologies related to emotional states and the gamification impact on those states.

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Requirements Engineering for Pervasive Games Based Smart Learning Systems

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Abstract. The overlap of different features of pervasive games based smart learning systems (PGBSLSs) including the ludic aspect, the pervasive aspect and the educational aspect adds complexity to use requirements at design time and Runtime. Many methodologies and frameworks that make use of requirements models can be found in the literature, but very few of them use ontologies to ground the models that are used in PGBSLSs development. We propose in this paper a semantic model in the requirements engineering process in order to improve the development of PGBSLSs.

Keywords: Pervasive games, Smart Learning, Requirements Engineering, Ontology.

1 Introduction

A game is a formal description of strategic situation. Katie Salen and Eric Zimmerman [1] define a game as a system in which players engage in an artificial conflict, defined by rules, which result in a quantifiable outcome. As defined in the Oxford dictionary [2]: a game is a physical or mental activity, not imposed, not for any utilitarian purpose, to which it is engaged to entertain and draw pleasure. When the game has terminals like tablets, iPhone, social networks, etc., it is a video game.

Beyond the simple pleasure of play, one of the video game categories is the serious games [3] [4], they are used to meet medical needs, environmental needs, educational needs, etc. Serious games combine ludic and serious aspect [5] [6]. A serious game is a learning process, is a game, is an application of video game technologies, targets multiple learning objectives (to teach, train, educate, heal), applies in almost every field (education, health, advertising etc.) and it is intended for all age groups (children, adolescents and adults) [7]. So, in conclusion, serious games can be an effective tool to transmit educational content to learners. The integration of ubiquitous computing in game industry, the intersection of urban phenomena such as mobile technology, fiction, reality and taking into account the context allows producing the pervasive games. These offer a game experience combining real and virtual worlds. According to Markus Montola [8], "Pervasive

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game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally".

Those dimensions of pervasive games distinguished by Montola [9], are supposed to be built for fun and educational dimensions and turn into an instrument promoting smart learning systems. Indeed, by blending of real and virtual elements and enabling players to physically interact with their surroundings during the play, learners can become fully involved in and attain better learning outcomes. In fact, Contexts include the interactions between learners and environments. Therefore, pervasive games based smart learning systems "PGBSLSs" can be regarded as the technology enhanced learning that is capable of advising learners to learn in the real world with access to the digital world resources.

Nowadays, the development of PGBSLSs has become one of the important issues of technology enhanced learning. In fact, the number of functionalities and the options that accompany it is increased. Indeed, PGBSLSs often provide the players a changing experience that depend on where they are, what they are doing and how they feel. Initially, PGBSLSs developers are only interested in the use of location data, but now they are looking to expand the system limits to all the three dimensions: spatial, temporal and social. Face to those conditions, the requirements must be formalized so that it can then be checked and updated. This requires a flexible formalism that adapts to the dynamicity of the context. This problem has motivated us to propose an ontology of requirements on the use of PGBSLSs Requirements. The objective and contribution of this work is to provide, through the proposed ontology, a formal representation of requirements, giving a precise description of the domain entities and establishing a common vocabulary to be used by developers and stakeholders for better communication.

The paper is organized as follows: the second section presents background about RE and Ontological Engineering and the motivation. Section three presents the related works. Section four presents the proposed RE method. Finally the fifth section reports on the progress and the future works.

2 Background and Motivation

2.1 Requirements Engineering

A requirement prescribes a property judged necessary for the system. The IEEE Standard Glossary of Software Engineering Terminology [10] defines a requirement as: (1) A condition or capability needed by a user to solve a problem or achieve an objective. (2) A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents. (3) A documented representation of a condition or capability as in (1) or (2). The term requirement has a strong overloading in the Requirements Engineering literature (RE). Requirements Engineering (RE) is the first fundamental step of any project of system development. According to GTIE (Working Group on Requirements Engineering) of the AFIS (French Association of Systems Engineering) [11], RE means all activities to discover, analyze, validate and evolving a set of requirements for a system. RE is essentially based on communication between different participants. The main objective is to enable a common understanding by the various project stakeholders, to design the system. Stakeholders are people, organizations, or objects that are directly or indirectly involved with our project. They can either affect or be affected by our project or system, which means they are important to identify.

2.2 Ontological Engineering

The word ontology comes from the Greek ontos (being) and logos (word). It denotes the science of being and the descriptions for the organization, designation and categorization of existence [12]. Carried over to computer science in the field of artificial intelligence and information technologies, an ontology is understood as a representational artifact for specifying the semantics or meaning about the information or knowledge in a certain domain in a structured form [13]. In fact, ontologies provide a formal representation of knowledge and the relationships between concepts.

Since ontologies [14] allow formally presenting knowledge, describe the reasoning on that knowledge, sharing and reusing, we propose, in this research, using ontologies in the process of requirements engineering for PGBSLS development. An ontology is an explicit specification of a conceptualization [15]. It can be used for both, to describe requirements specification documents [16, 17] and formally represent requirements knowledge [18, 19]. In contrast to traditional knowledge-based approaches, e.g. formal specification languages, ontologies seem to be well suited for an evolutionary approach to the specification of requirements and domain knowledge [19]. Moreover, ontologies can be used to support requirements management and traceability [16, 18]. Automated validation and consistency checking are considered as a potential benefit compared to semi-formal or informal approaches providing no logical formalism or model theory.

2.3 PGBSLSs Requirements

PGBSLSs are large scale systems because they operate in highly dynamic environments. When developing such systems, it is very important to undertaken user requirements. PGBSLSs are closely related to context, they can be played in various contexts. Context information, exhibits a diverse array of frequent changes and dynamic information. Indeed, any action in the real world can be a game action, and any comments sense of the players could be considered as a part of the game.

Requirements of PGBSLSs players vary from one context to another in which they are situated. What is important isn't to capture and treat of context but what is important is to be able to offer instant and adaptive support by immediate analyses of the needs of individual players. For example, a player's location and activity often change from one minute o the next and from one objective to another. As another example, a player wants to play with real human beings in the same way that they would interact with them in the real world. Sometimes, the player needs to move in all location-based games like Can You See Me Now [20] and Uncle Roy All Around You [21]. Often, their needs change. QuaGauntlet [21] is a good example of a game in which the players need to change their postures to aim, fire, and activate their shields.

The requirements engineers capture the demands of the players to fix their preferences and to adapt PGBSLSs scenario to their needs. But, during the runtime of PGBSLSs, it is difficult for the analyst to know in advance what to change?, For whom?, when? Why?, etc.

To fill this shortcoming, a semantic model may be useful in at least two levels [22]. First, at the design time, it constitutes a reference frame, both to facilitate communication within the design team and to allow the possible redesign and / or the reuse of parts of the system. Second, at the run time, so as it is charged to vary the parameters and characteristics of the system.

3 Related work

Only little research concerning the modeling of PGBSLSs requirements is found. Chen and Shih [23] proposed a prototype of a meta-model which puts together several partial perspectives of the Instructional Pervasive Games (IPG) and made a set of checklist as the reference for IPG developers. Context requirement, pedagogy requirement, and design requirement form the main body of the meta-model. With this mega model, a structured guideline for IPG designers can be drawn. Laine and al. [24], illustrated a "technology integration model" for game-based pervasive learning systems, stated that an IPG needs to meet the following requirement: 1) Pedagogical requirements, include user profile, interaction and collaboration, ownership, authenticity and relevance, finally, support and assessment; 2) Game design requirements, include Resources, financial and human, cultural issues, technical issues, environmental issues, social issues and temporal issues; and 3) Context requirements, include Context-awareness, dynamics, interaction, and content. Those requirements should be met by the integrated technology.

Serral [25] presented a hybrid approach to develop full functional context-aware pervasive systems. She proposed a set of graphical OO1 models for capturing the requirements of the system and its context available at modelling time, and a context ontology for managing context at runtime.

On the requirement analysis for context aware systems, there have been a couple of works. Hannes [26] noticed the importance of context in use case creation, and so introduced a process to capture context situations. The main goal of the process is bridging the gap between critical context situations and the user goal by identifying the situations. Lyubov [27] introduced requirement engineering for pervasive services, and proposed a method for obtaining requirements for context-aware systems under development.

Other approaches exist in the domain of RE, some of them are designed specifically for pervasive systems. Those approaches take into account the characteristics of ambient intelligence and ubiquitous computing as context awareness, personalization or dynamics, etc. Sitou and Spanfelner [28] presented a model based on requirements engineering to analyze and specify the basic behavior of the system and the adaptive behavior based on the needs of the customers. The approach is based on the elicitation, analysis and specification of different parts of the context adaptive systems. The model enriches the context with aspects of participants, activities, changing behavior change, etc. This model consists of a user model, a task model, a domain model, a platform model, a model of dialogue and a presentation template.

Most of the works described previously don't exploit ontologies like the work of Chen, others approaches are based on UML like Tesina's work. Although ontologies have attracted much attention recently, the various existing approaches, using ontologies, are characterized by specificity and limits of developed ontologies. Generally, developers define domain ontologies which vary in their degree of generality (business level) and in their degree of specificity (technical level). They also vary in their coverage of aspects of the modeled systems. As we know, none of those approaches has considered the use of requirements ontologies in the PGBSLSs development process which causes a generic and an incomplete definition of requirements and requires the participation of actors with different skills (Analysts, Architects, etc.).

4 The Proposed RE method

Our goal is to take advantage of the existing knowledge and propose mechanisms and techniques to use them in an approach that guides the definition and analysis of PGBSLSs requirements. In this context, Castaneda et al [29] describes the benefits and challenges of using ontologies in the process of requirements engineering (RE). This is exactly the basis of our approach. Indeed, RE imposes a systematic series of activities to be conducted on the requirements. Our approach takes those activities but adapts them for the definition of PGBSLS requirements.

4.1 The Requirements Elicitation

Because requirements elicitation is a relatively principal step of requirements engineering process, we suggest reviewing the literature to study the areas of learning systems and pervasive games. The result of this step consists of a first set of textual PGBSLSs requirements. We have broken the requirements into two categories of requirements which are pervasive games requirements and learning requirements.

Literature review was conducted to get requirements for the development of PGBSLSs. Unfortunately, no publications dealing with requirements could be found in scientific literature. Instead, a list of PGBSLSs influencing factors could be identified, which have an effect on the learning success and on the motivation of players. In fact, for understanding the pervasive games properties, we have studied the works of [30], [31], [32], [33] and [34]. The notion of context is thus essential in pervasive games as they must also be sensitive to the context in order to adapt to the pervasive environment in which they operate. Taking into account the context requires an understanding of the concept. We have focused on the researches of [35], [36], [37] in order to analyze the contextual properties.
Understanding of "learning" aspect is the first step towards defining requirements of learning. Indeed, Learning is the activity or process of gaining knowledge or skills by studying, practicing, being taught, or experiencing something. The researches of [38], [39], [40], [41] [42], [43], [44] and [45] give details about the concept of learning scenario.

The result of the elicitation step is a corpus. A corpus is a collection of documents [46]. Our corpus is collected from the aforementioned researches. The next figure presents the PGBSLSs knowledge corpus.

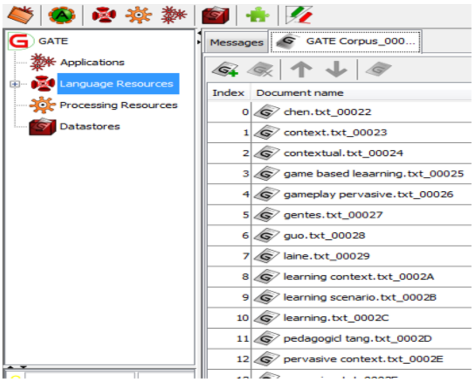

Fig. 3. PGBSLSs knowledge corpus

4.2 The Requirements Analysis

The acquisition of the PGBSLSs knowledge started from the previous corpus (section 4.1). So, those documents have been analyzed and at the current stage of our research we have deducted twenty requirements. Among those requirements, we can mention the next examples:

Requirements of pervasive games.

- A PGBSLS allow the players to play in fixed time and fixed round or open ended time or open ended round,
- A PGBSLS allow the player to focuse on a clear goal,
- A PGBSLS can be played where the player must move in one place and physical actions are needed to change gesture, posture, etc. due to the requirements of gameplay, etc.

Requirements of Learning.

- A PGBSLS must offer a content to learn,
- A PGBSLS must offer a structured content,
- A PGBSLS should dispose players with resource, etc.

4.3 The Requirements Specification

In the specification step, requirements are registered, documented and formalized accordingly to the Requirements Ontology. There are a number of methods and methodologies one can employ to develop their own ontology in a domain. Among those methods [47] we find CyKB, Uschold and King's method, Grϋninger and Fox's method, the KACTUS project method, Sensus's method, METHONTOLOGY, the On-To-Knowledge methodology and CO4 protocol. For starting point, Noy & McGuinness's presented a guide to create ontologies. In this paper, we have adopted Noy & McGuinness's method to build our ontology of requirements due to the simplicity of the method. Noy & McGuinness's seven steps method requires one to [48]: 1. Determine the domain, scope and purpose of the ontology; 2. Consider reusing existing ontologies; 3. Enumerate important terms in the ontology; 4. Define the classes and the class hierarchy; 5. Define the properties of the classes – slots; 6. Define the facets of the slots; and finally 7. Create the instances. The next figure represents an extract of a domain range view of our ontology of requirements. It shows the properties with different OWL (Web Ontology Language) classes. For example the player has a time,a space and a round. The closed arrows in this figure represent the rules (axioms) written in Semantic Web Rule Language (SWRL).

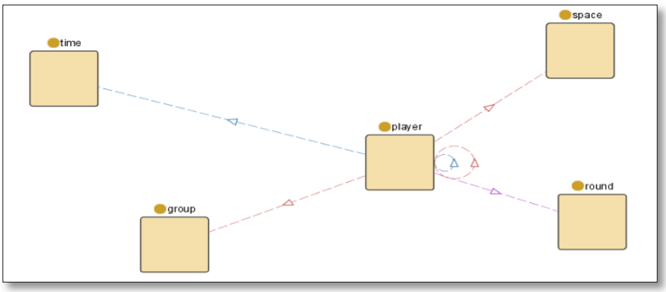

Fig. 3. An extract of a domain range view of the PGBSLSs requirements ontology

4.4 The Requirements Validation

Given that our goal was to develop an ontology covering the high-level concepts of PGBSLSs, the focus, in this step, is to test the incorporation of ontologies in the process of defining PGBSLSs requirements. We focus on a case study in order to validate the feasibility of our proposed approach following the criteria of completeness, validity and usability. The completeness criterion is achieved by mapping the ontology of requirements and an ontology of domain from literature. The validity criterion is evaluated by requests of RO using its terminology and its capacity to response. Finally, the usability criterion is validated by using the RO in a real project.

5 Conclusion

This research is located at the intersection of three major scientific domains: requirement engineering, ontological engineering and PGBSLSs development. The main idea of our approach is an ontology of requirements following the requirements engineering process. The first step was to collect PGBSLSs requirements by gathering related researches. Then we built a set of identified requirements following the two dimensions which are pervasive games and learning systems but they aren't formalized. After that, we specified the concepts, the relations and the axioms of our ontology of requirements. We are currently testing the incorporation of the ontology of requirements in the process of defining requirements by relying on a case study.

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MOOCs Recommender System: A Recommender System for the Massive Open Online Courses.

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Abstract. Nowadays, technology is affecting every aspect of our society in different manner. However, the technology impact is more tangible in the field of education. Technological advances are transforming the way education is being delivered. Courses are not limited for those who are attending university or school classes. The proliferation of Web Technologies and the exploration of the possibilities of Technology Enhance Learning (TEL) led to the development of many learning solutions and recently to Massive Open Online Courses (MOOCs). MOOCs are capable of providing several ten thousands of learners with access to courses over the web. Recently, there are many MOOCs providers/platforms with different features and characteristics. Online learners are exposed to various challenges with this excess of those MOOCs providers. This paper presents a system that is built in the top of MOOCs providers to act as a single point of access to those providers. This system is twofold: first, it will improve the learning process for any online learner in a way that satisfies the learner needs when searching for suitable courses among different providers; It will help users not to be lost in the overwhelming offers of MOOCs. Second, it will recommend courses related to the previous experiences of its users.

Keywords: MOOCs; MOOCs providers/Platforms; Online Lerner; e-Learning; Recommender System.

1 Introduction

Technology Enhanced Learning (TEL) introduces the use of technology for the learning purposes. In particular, Web Technologies have significantly enhanced learning over the internet. Web Technologies led to the development of many web learning solutions and recently to Massive Open Online Courses (MOOCs). MOOC presents a new opportunity to be part of a learning community, often led by key voices in education.

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MOOCs provide a new way of learning, which is open, participatory, distributed and lifelong [1]. MOOCs have recently gained much attention especially in leading universities and are now often considered a highly promising form of teaching. Also, the number of online MOOCs learners is rapidly growing [2].

On another side, this huge number of available and open resources led us to think on the way to help learners to not be lost. Learners need to find the most suitable course among all proposed on the web, and to prevent them from being overwhelmed by the huge amounts of resources.

Since information retrieval and searching for the appropriate learning resources is an essential activity in TEL, the development of a recommender portal can be seen as a solution.

Recommender systems permit to respond to a traditional problem in TEL which is “finding the best learning resources” for the learner. With MOOCs proliferation this traditional problem is more than ever up to date. Learners will be exposed to various challenges with this excess of learning resources: Which provider they have to choose to search for a specific MOOC? Who is the best provider? How to search a specific MOOC? … etc.

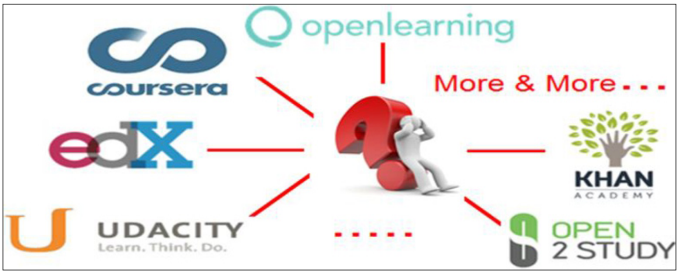

Fig.1. Many MOOCs providers with varity of chocess.

In practice, all MOOCs users would try to find services that help them identify suitable learning resources from this overwhelming variety of choices (figure 2).

In this paper, we introduce our system which is built in the top of MOOCs providers to act as a single point of access to those providers. This will be as a service for any online learner to help them identify suitable learning resources.

2 System description

Our system is a web-based application that provides appropriate courses in response to a learner request from different MOOCs providers. Currently and as a start point, we covers 2 MOOCs providers (Coursera and openLearning), in future, more provider can be added.

The system aims to act as a middle point between learners and MOOCs providers.

Moreover, the system suggests for each course other course(s) that is (are) commonly taking with by other learners.

This system aims to improve and upgrade the efficiency level of the learning and training in the e-learning side. In addition, it aims to facilitate the learning process, improve the learning outcomes, as well as provide a good learning environment.

Since the user interface is one of the most important parts of any application, we aimed to make the interface of MOOCs Recommender system as friendly as possible. Each interface is designed to be easy and intuitive in order to help learners in navigating the whole system and finding courses easily to increase our learners' satisfaction.

MOOCs Recommender system has two views which are the Guests view and the Member view. In both views the learner is guaranteed with the main function which is : find courses and learn across many providers. Furthermore, it allows both users to find the recommended courses based on the experience of other learners.

The difference between the two views is that when the user logged in (Member view) he/she can his/her history about learned and searched courses. Moreover, he/she can perform several functions, including: mark course as read later, identify courses as completed, and view a learning progress report.

Figure 4 shows the main interface of the system.

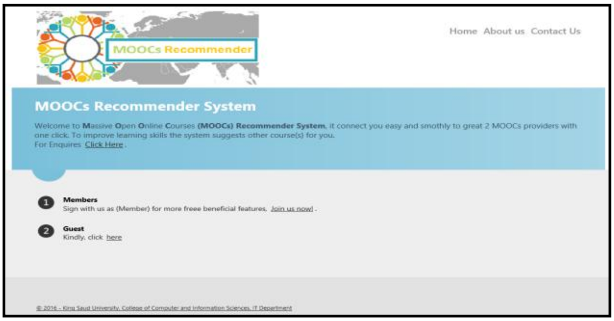

Fig.2. System Main Interface.

Everyone believes that it is very important to engage the learner when they land on an error in order to achieve a highly efficiency. Make them want to try again to obtain learning in our site. We made our own interactive error page. Our learner will be redirected to it when any error happened.

Based on [3], error page shall provide the end user with a hyperlink back to your website or a navigation. We designed our error page based on this point of view (See Figure 5). In this way, our learner will be comfortable even when the error occurs.

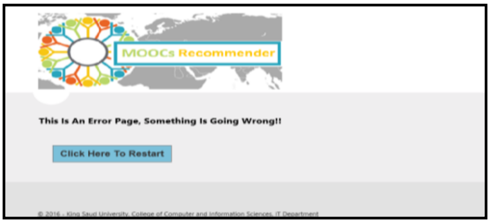

Fig.3. System Error Handler Page.

3 System Integration

The main goal of system integration is to go smoothly without any problems and to insure that the system apply its functionalities in an efficient way. MOOCs Recommender System is implemented using an incremental model, where the implementation process went throw multiple development cycles.

Cycles are divided up into smaller, more easily managed modules. Each module passes through the requirements, design, implementation and testing phases. So when we finish with the implementation we did not need much integration and testing for the system functions.

4 Conclusion and Future Work

In this paper, in one hand, we presented MOOCs platforms study toward building MOOCs Recommender portal. As a result we recommend –as a starting point- to build MOOCs Recommender portal on the top of Coursera and Openlearning then the scope can be expanded to include more and more MOOCs provider using their APIs. Coursera and Openlearning are similar in many ways regarding their web sites for instance the features they are providing and their APIs representations.

In another hand, this study facilitated the development of our recommender portal which is currently in the real life testing phase.

This system is twofold: first, it will improve the learning process for any online learner in a way that satisfies the learner needs when searching for suitable courses among different providers; It will help users not to be lost in the overwhelming offers of MOOCs. Second, it will recommend courses related to the previous experiences of its users.

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Integrating a Peer Evaluation Module in a Social Learning Platform

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Abstract. Peer review is a valuable educational activity, especially in social learning settings, group work and project-based learning scenarios. It has the potential to foster critical thinking and reflection, expand students' perspectives and understanding and increase engagement and interactivity. Several software tools for supporting the student peer review process have been proposed so far, but few of them are integrated in an all-encompassing learning environment. Therefore, our proposal is to extend an existing fully-fledged social learning platform, called eMUSE, with a peer evaluation module; the tool offers a wide range of functionalities, both for the student and the instructor. The peer evaluation is closely integrated with the educational social media tools and the project-based learning scenario; rather than focusing on a single written assignment, the module supports a more in-depth monitoring and assessment of peers' work. The platform has been successfully used in practice and preliminary evaluation results are reported in the paper.

Keywords: Peer assessment · Social learning environment · Project-based learning

1 Introduction

Peer evaluation is gaining increasing popularity in recent years, especially in the context of collaborative learning [12]. Also known as peer review or peer assessment, it refers to the involvement of students in the process of evaluating the work of fellow learners and providing feedback and sometimes grades [18].

Peer review has several benefits, both for the provider and the receiver of the assessment. Students who play the role of evaluators are exposed to peers' work and ideas, which offers them new perspectives on the field [11] and helps them extend their own knowledge and understanding [7, 17]. Furthermore, performing an evaluation contributes to the development of advanced critical thinking, reflection and meta-cognitive skills [10]. It also improves evaluators' motivation and responsibility [5] and fosters self-confidence [4]. Students who receive their peers' reviews benefit from timely and more detailed feedback, as compared to the

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limited formative assessment which can be provided by the instructor, especially in large classes [10].

Nevertheless, peer review also has potential pitfalls, such as validity, reliability and fairness issues, especially in case of peer grading [12]. Some students may resent evaluating their peers' work [2], find it too time consuming or lack confidence in their evaluation ability [12]; other students may not take the peer review process seriously, unless it is monitored and graded by the instructor [9].

However, on the whole, students' engagement is increased by means of peer evaluation, since their motivation for learning has a strong social dimension [20] and they pay more attention to peers' opinions and feedback [6]. Furthermore, an increased interactivity level between students and a more active role in learning are achieved [12].

Therefore, peer review is especially appropriate in social learning settings, in group work and project-based learning scenarios [19]. In this context, what we propose in this paper is the integration of a peer review module in an existing social learning platform. Several online tools for peer review are already available, but they are generally stand-alone platforms, having peer evaluation as their exclusive purpose. By contrast, our goal is to offer a broader learning environment, which integrates formative peer assessment alongside educational social media tools.

The rest of the paper is structured as follows: an overview of related work is included in the next section. Our solution for the peer evaluation module is described in section 3. Subsequently, an initial experimental validation of the tool is reported in section 4. Finally, some conclusions and future research directions are included in section 5.

2 Related Work

Several web-based tools for managing the student peer review process have been proposed so far, as summarized in [3, 12]. Some of the most recent systems include:

- CrowdGrader [1] – an online platform for collaborative evaluation of homework solutions
- CaptainTeach [13] – a peer review system for programming assignments
- Mechanical TA [22] – an automated peer review tool for essay grading.

All these systems are dedicated exclusively to peer review management, and require the explicit upload of student work for review. More closely related to our proposal are the all-encompassing educational systems, which integrate the peer review module among their other learning support functionalities. Such an example is the GRAASP social media platform, which offers support for communities of practice and collaborative learning activities. A simple extension for automating reviewer tasks was included in the platform, as described in [21]. Students can create a space in GRAASP to upload their work in it and the instructor invites randomly assigned peers into that space to perform the review. A basic 5-point Likert-type scale is used for rating the work and an average score is computed by the platform [21].

Another example is MyProject, an adaptive educational system designed to support project-based learning [3]. The educational activities are organized in four different stages: Introduction, Generate Ideas, Multiple Perspectives & Research, and Solution & Evaluation. Various peer assessment functionalities are integrated throughout this learning cycle, including analytical reviews and grading, back-reviews or short agreement statements; students may also submit revised versions of the final deliverable, based on the reviews received.

Finally, some learning management systems also integrate modules for peer evaluation, such as *Workshop activity* in Moodle[1] or *Self and Peer Assessment* tool in Blackboard[2]. Similarly, MOOC platforms (such as Coursera[3] and EdX[4]) include some predefined spaces for peer review.

By contrast, the peer evaluation module that we propose is designed in the context of a social learning environment, in a close integration with the rest of the educational activities and the social media tools, as described in the next section.

3 Peer Evaluation Module in eMUSE 2.0

3.1 eMUSE Social Learning Environment

The social learning platform that we start from is eMUSE [15], which integrates several popular social media tools (such as Blogger, MediaWiki, Twitter, Delicious, YouTube or SlideShare) and also provides value-added services for both students and teachers. From the students' point of view, eMUSE offers the following main functionalities:

- Integrated learning space, with a common access point to all the social media tools selected by the instructor, including updates of the latest peer activity
- Summary of each student's involvement, including charts, comparisons with peers, as well as aggregated data
- Preliminary score computed based on the recorded student activity, following teacher-defined criteria [15].

As far as the instructor is concerned, eMUSE acts as a control panel, with the following main functionalities:

[1] https://docs.moodle.org/30/en/Workshop_activity
[2] http://www.niu.edu/blackboard/assess/spa.shtml
[3] https://learner.coursera.help/hc/en-us/sections/201895903-Peer-reviewed-assignments
[4] http://edx.readthedocs.io/projects/edx-guide-for-students/en/latest/SFD_ORA.html

- Configure the course, by setting up the associated learning scenario and selecting the social media tools to be used
- Student management (course enrolment, centralized access to students' accounts on each social media tool, grading information)
- Collect data on students' activity on the social media tools, search and browse students' actions, configure grading scheme, visualize course statistics, detailed charts of student involvement and comparative evaluations [15].

From a technical point of view, the integration of the social media tools into the platform was done by means of *mashups*, as reflected also in its name (**e**mpowering **M**ash**U**ps for **S**ocial **E**-learning). The first version of the platform was proposed in [14]; it was subsequently re-engineered, extended and improved, leading to a new version, eMUSE 2.0. A peer assessment module is one of the main functionalities added to the platform, with the goal to increase students' engagement and motivation; a continuous monitoring and evaluation of students' work and activity by their peers is thus facilitated. The module caters for the needs of the students, but also of the instructor, as detailed in the next subsections.

3.2 Functionalities for the Instructor

The peer evaluation module offers the instructor the possibility to easily create evaluation form templates, which include several types of review rubrics: open ended questions, single-choice questions, multiple choice questions. The interface is very simple, based on a drag-and-drop functionality, as illustrated in Fig. 1. The single-choice questions may include rating options, which can be thereafter used by the system for computing average grades.

Instructors can subsequently assign the review forms to the students, creating the desired evaluator / evaluated pairs. Team support is provided as well, since both individual students and whole teams can be the subject of evaluation. Once assigned, the status of evaluation forms (pending, completed, with feedback) can be monitored by the instructor, who can search and filter them accordingly. The instructor can also visualize all completed student evaluations and provide feedback to the evaluator as appropriate.

Finally, the module provides the instructor with various reports and statistics, e.g., average scores obtained by a student for each review rubric, charts with all ratings obtained by a student for a particular evaluation (as illustrated in Fig. 2).

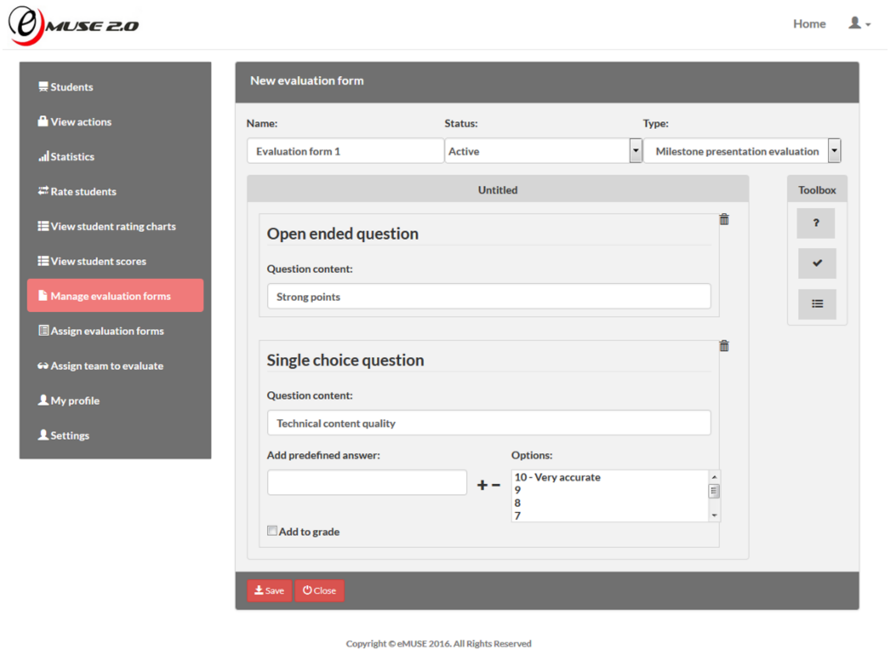

Fig. 1. eMUSE 2.0 evaluation module (instructor perspective) – review form creation

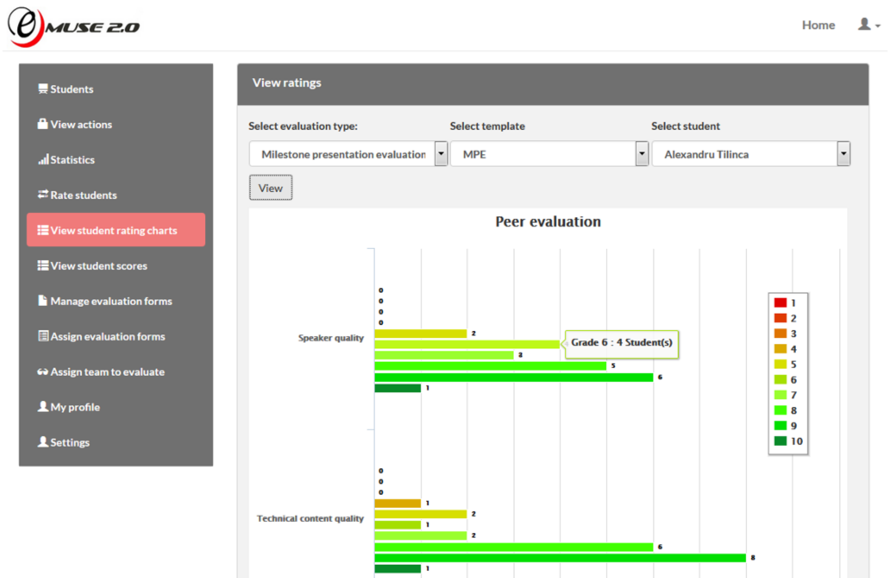

Fig. 2. eMUSE 2.0 evaluation module (instructor perspective) – graphical visualization of student scores

3.3 Functionalities for the Student

The peer evaluation module provides students with the possibility to visualize the evaluation forms assigned to them and fill them in (as shown in Fig. 3a). A single blind review approach is used, in which the evaluators remain anonymous. In order to help students monitor their peers' activity on the social media tools, a list of student actions with various filters and search options is made available to the evaluator; furthermore, various activity charts are provided, as illustrated in Fig. 3b. Notification emails are sent to evaluators with overdue review assignments, in order to increase participation.

Students can visualize the evaluations received from their peers and give a back-review (i.e., send feedback to the evaluator regarding the quality of the review received, including rebuttal or additional explanations). Students are automatically notified by email when they receive an evaluation response. This feedback can help learners improve their assessment skills and also better understand their peers' perspectives. At the same time, evaluators can visualize the reviews performed by others for the same student or team (in an anonymous way); this mechanism fosters critical thinking and helps students understand their evaluation shortcomings, by providing different points of view and comparison standards.

Just like in case of instructors, the module offers students various reports and statistics, such as average scores received for each evaluation rubric or charts with all the ratings obtained for a particular evaluation.

4 Initial Experimental Validation

The new eMUSE 2.0 platform was initially introduced to 75 undergraduate students from the University of Craiova, who were enrolled in a Web Applications Design course. A collaborative project-based learning scenario was implemented, following successful similar course runs in previous years [15, 16]. Students worked in teams of 3-4 peers to design and implement a web application of their choice (e.g., a virtual bookstore, an online auction website, a professional social network, an online travel agency, etc.).

A blended mode approach was used; in addition to face-to-face classes, students relied on eMUSE 2.0 and three integrated social media tools for communication and collaboration support. Thus, a wiki platform (i.e., MediaWiki) was used for collaborative writing tasks, for gathering and organizing knowledge and resources, and for documenting the project. A blogging tool (i.e., Blogger) was employed as a "learning diary", for reporting the progress of each project, for publishing ideas and resources, as well as for providing feedback and solutions to peer problems; each team had its own blog, but inter-team cooperation was encouraged as well. Finally, a microblogging tool (i.e., Twitter) was used for posting short news,

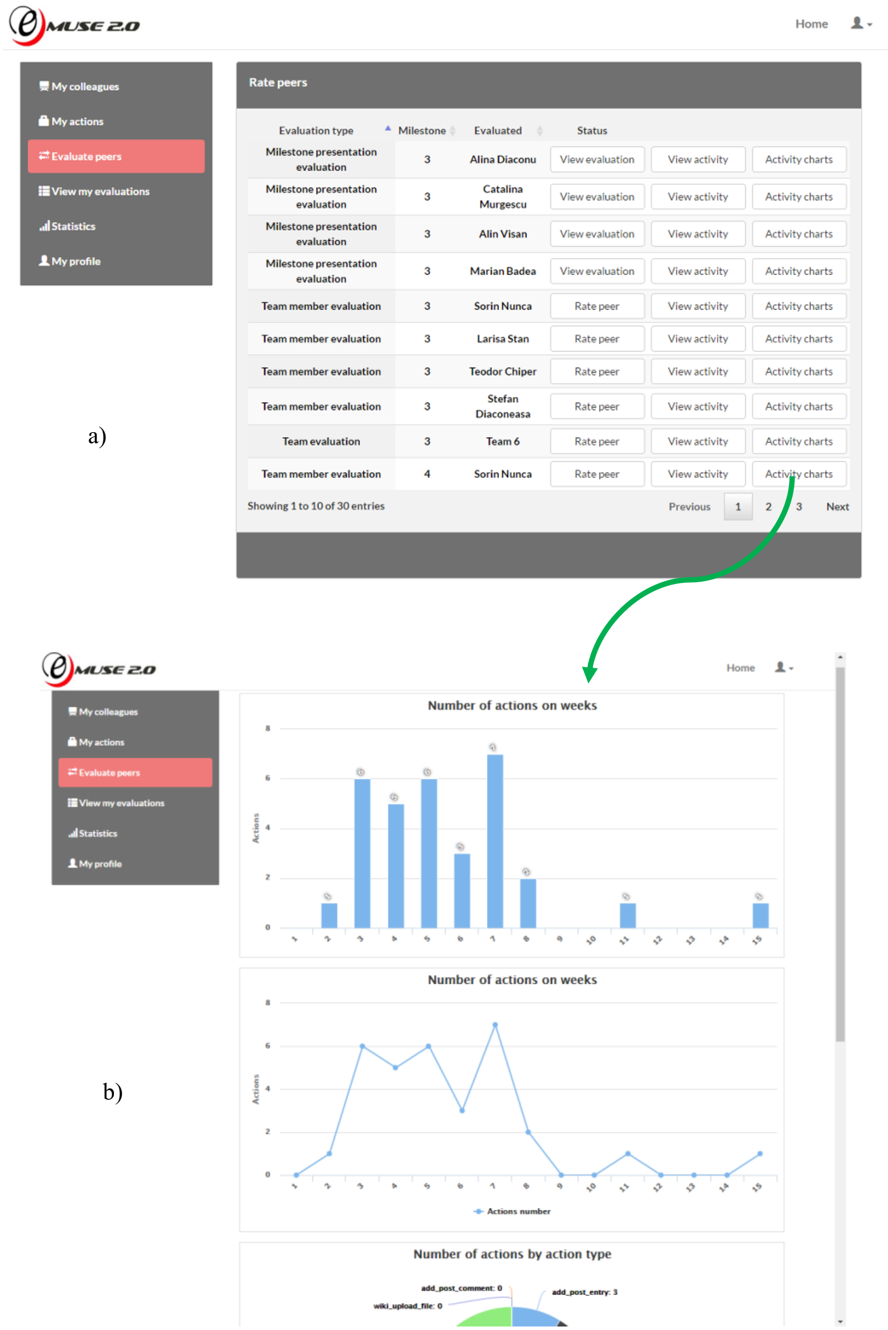

Fig. 3. eMUSE 2.0 evaluation module (student perspective) – (a) list of assigned evaluation forms; (b) activity charts for evaluated student

announcements, questions, and status updates regarding each project. There were also four intermediary project presentations that each team had to deliver during face-to-face classes; their goal was to engage students more and discourage the practice of activity peak at the end of the semester. Grading took into account both the final project and the collaborative work carried throughout the semester.

A formative peer evaluation activity was integrated in the learning scenario. Thus, students were asked to assess the quality of their peers' work and presentations, for each intermediary milestone, as well as for the final product. Furthermore, each student had one team assigned for evaluation, whose work they had to follow throughout the semester; both individual contributions and overall team activity were monitored and assessed. In the first part of the semester, Google Forms were used by the instructor for creating the evaluation forms. In the second part of the semester, eMUSE 2.0 was made available to the students, including the built-in peer evaluation module.

At the end of the semester, students were asked to fill in a survey regarding their overall learning experience. Fifty-nine students completed this questionnaire, and in what follows we summarize their opinions regarding the introduction of the eMUSE 2.0 peer evaluation module. When asked to compare this peer review mechanism with the one based on Google Forms, the majority of students reported an increased level of usefulness, ease of use, convenience and overall satisfaction. A summary of their answers is included in Table 1.

Table 1. Percentages of students' answers to the question: "Please compare the peer evaluation mechanism included in eMUSE 2.0 (that you used in the second part of the semester) with the one based on Google Forms (that you used in the first part of the semester)"

	A lot higher	Somewhat higher	The same	Somewhat lower	A lot lower
Ease of use	33.9 %	37.3 %	16.9 %	8.5 %	3.4 %
Usefulness	28.8 %	42.4 %	22.0 %	5.1 %	1.7 %
Convenience	35.6 %	39.0 %	20.3 %	3.4 %	1.7 %
Overall satisfaction	30.5 %	44.1 %	18.6 %	1.7 %	5.1 %

In addition, students pointed out several advantages of the eMUSE 2.0 peer evaluation module: i) possibility to monitor the evaluated peers' activity on the social media tools, with useful filter and graphical visualization options; ii) easier access to the evaluation forms from a centralized location; iii) more user-friendly visualization of received reviews; iv) possibility to give feedback for an evaluation; v) more efficient approach, due to the pre-filled data (evaluator name, milestone number, information regarding the evaluated student/team); vi) easier way to keep track of the pending evaluations. The main disadvantage mentioned by the students referred to eMUSE 2.0 minor bugs and server unavailability issues, caused by its beta release status.

Overall, the initial evaluation results are very encouraging; a large majority of students (over 80%) reported their preference to use the eMUSE 2.0 peer evaluation module in the future.

5 Conclusion

We designed and implemented a peer evaluation module integrated in the eMUSE social learning platform; the tool offers a wide range of functionalities, both for the student and the instructor. Unlike similar systems, the module supports a more in-depth monitoring and evaluation of peers' overall activity, not just of one output (e.g., an essay or open answer assignment). Furthermore, the evaluation can be closely integrated with the project-based learning scenario and the educational social media tools. In addition, the teacher can create and customize the desired evaluation forms, appropriate for each activity type (rather than use predefined ones); various graphical visualizations of student scores are also provided. The eMUSE 2.0 peer evaluation module has been used by 75 students in a pilot study, with promising results.

More extensive experimental studies are envisaged. Furthermore, we plan to conduct an in-depth analysis of the quality and usefulness of the peer reviews performed by the students. Finally, following the suggestions in [8], the peer evaluation module could be extended with various calibration, reputation and meta-reviewing mechanisms.

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The Effects of Perceived Innovation Game Attributes by Learners on Learning Performance in a Game-Based Achievement Learning System

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Abstract. This study investigated how the perceived innovation game attributes by learners influence their learning performance in a game-based achievement learning system. A total of 51 learners participated in a ‘‘game-based achievement learning system” developed for the purpose of the study with innovation game attributes to facilitate meaningful learning. Hypotheses were tested and data were analyzed using regression analysis and independent samples t-test. The results revealed that the perceived innovation game attributes by the learners had a significant influence on learning performance in the game-based achievement learning system. Furthermore, based on Roger’s diffusion of innovation (DOI) theory, this study also investigated whether the learners’ perceived innovation game attributes and learning performance have some sort of relationship with stage of game adoption (i.e., earlier and later). A subsequent analysis showed that the learners who were late game adopters significantly outperformed those learners who were early adopters. Discussion of the results and the implications of this study are also presented.

Keywords: Innovation game attributes. Game-based achievement learning system. Learning performance. Diffusion of innovation (DOI)

1 Introduction

Innovation technology has been regarded as a promising alternative for learning and teaching in recent years. These innovative technologies, such as Web 2.0 [1], computer-mediated communication [2], and game-based learning [3] have been developed to facilitate more efficient learning and teaching. For example, Web 2.0 provides a wide exploration of technology for learning, and researchers are focusing on using the innovations of wiki, audio and video conferencing, mobile technologies, and virtual worlds to enhance learning [4].

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In recent years, game-based learning has become one of the most popular [5] and widely used [6] innovative applications, and seems likely to continue to be adopted. Recently developed educational games engage learners in various activities and foster interactivity [7], feedback [8], knowledge construction [9], and extra motivation to engage in learning [10]. Such facilities may enhance learners' interest in adopting game-based learning activities for continuing learning. As Rogers [11] mentioned, people need to recognize at least some of the relative advantages of innovative technology usage before they can make the decision to learn from it. Thus, this study developed a game-based achievement learning system with relative advantages, less complex usage and a trialability preference which may facilitate learners' adoption and continual learning from the system. Although a few studies have attempted to determine the acceptance of games in learning environments or the factors affecting game adoption, there is still a lack of acceptance [12]. Therefore, this study aimed to investigate how perceived innovation game attributes by the learners would influence their learning performance when using a game-based achievement learning system.

In addition, not all people adopt innovative technology at the same time [11]; for example, the adoption of playing computer games takes place at different points on a time scale. Therefore, this study also investigated the game adoption time sequence as well as the classification of adopter categories (i.e., earlier and later) based on the Diffusion of Innovation theory (DOI) proposed by Rogers [11] as the scheme of adopter categorization. These categories reflect the fact that games are adopted over a period of time, due to different kinds of online games, such as simulation games, role playing games, and shooting games [13] were investigated as an innovative acceptance to learners. Moreover, the adoption time sequence also depends on the game's consequences, availability and popularity. Therefore, this study aimed to investigate whether there are any significant differences in perceived innovation game attributes (i.e, relative advantage, complexity, and trialability) and learning performance between early and later adopters in the game-based achievement learning system. This study intended to explicate the following three research questions:

1. How do the learners' perceived innovation game attributes influence their learning performance in the game-based achievement learning system?
2. Are there any differences in the perceived game attributes between the early and later adopters in the game-based achievement learning system?
3. Is there any difference in the learning performance between the early and later adopters in the game-based achievement learning system?

2 Literature review

2.1 Innovation game attributes of the game-based achievement learning system and learning performance

There have been several studies investigating the acceptance of the innovation attributes of DGBL [12, 13, 14]. For example, Kebritchi [16] found that the innovation attributes in terms of relative advantage, complexity, and trialability had a significant influence on teachers' perceived adoption of a game, while Bourgonjon et al. [17] showed that learners' preferences for using video games were significantly affected by the characteristics of the innovation itself. Moreover, [14] revealed that the innovativeness of the game could predict a strong construct of online game adoption. On the other hand, Cheng, Lou, Kuo, and Shih [12] found that the implementation of the DGBL innovation was directly influenced by the learners' perceived ease of use and perceived usefulness of the innovation. With regard to scaffolding game-based learning, a flow condition was significantly observed, which was able to predict perceived learning and enjoyment [18], while Connolly, Stasfield, and Hainey [19] demonstrated an alternate reality game to facilitate foreign language learning, and found that learners were greatly motivated and positive regarding this learning experience, and were likely to further engage in the game context.

2.2 Adopter categories of perceived innovation game attributes and learning performance

Adoption category has been defined as "the classifications of members of a social system on the basis of innovativeness" [11]. Therefore, an early adopter, as defined in the current study, is a learner who is more likely to experience new ideas, and to try and engage in the innovation process.

In Cheng, Kao, and Lin [15], they examined different degrees of learner adoption of various digital games. The results revealed that earlier players, that is the early adopters, seemed to have more innovative thinking about digital games. Meanwhile, they appeared to be more curious and were able to acknowledge innovation quickly, which might have a corresponding positive influence on their learning performance. Moreover, a study from Baydas, Karakus, Topu, Yilmza, Ozturk, and Goktas [20] showed a result of significantly different retention scores for learners with different degrees of game experience. Their study found that learners with more game experience as early game adopters were more used to the game environment, which influenced their content retention, making their learning performance more effective.

3 Instructional design of the game-based achievement learning system

There are three main parts of the game-based achievement learning system including digital badges, leaderboard ranking, and learning practice with star icons, which provide continuous learning enhancement and inspiration with three learning planets (i.e., alphabet, word, and sentence) (see Fig. 1). In each planet there are five learning units, each including 10 multiple choice questions. The learner wins a badge by answering a question correctly. By obtaining digital badges, learners can reach the learning goal, but need to do a lot of practice in the process. There are three levels of badges, gold, silver, and bronze, which represent different levels of learning achievement. The badge, in other words, serves as positive reinforcement in the system to motivate students to improve their learning performance and to sustain learning toward the next level. Upon receiving a badge after accomplishing a unit, the learner can see his/her own collection of badges (Fig. 2), the top score in the unit, and the ranking of scores of other learners for that unit.

Fig. 1. Snapshot of the English learning content

Fig. 2. Learners' ranking on the leaderboard

The rule is that for each correct answer, a learner will get half a star (Fig 3.). A total of 5 stars can be gained in one unit in the game system, with a total of 75 stars in the five learning units under the three planets (see Fig 4.). The learners can continue practicing until they gain 5 stars in one unit, which requires correctly answering 10 questions. When the learners finish the alphabet planet, they need to go on to complete the word and then the sentence learning planets. If learners get three or more stars, the system will show a dollar amount at the end of the practice session. If the learner has more than 4 wrong answers, then s/he is disqualified from practicing, and an avatar suggests that that they read the material in the digital book (see Fig 5.).

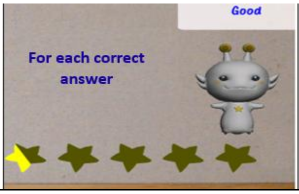

Fig. 3. Correctly answering a question

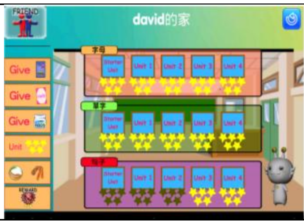

Fig. 4. Learning unit with star icons

Fig. 5. Try reading more

4 Methods

4.1 Participants and instruments

The participants were third grade students of an elementary school in northern Taiwan. A total of 51 students participated in this study. There were 26 (51%) boys and 25 (49%) girls. The participants were 9 to 10 years old. They all had the basic computing skills needed to play digital games.

Two kinds of research instruments were used in this study. The first was a questionnaire, which was developed to survey the learners' perceptions of the innovation game attributes (i.e., 10 items) to learn English while using the game-based achievement learning system. Each item was rated on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha for the innovation attribute items was over .60. The second instrument was the learning activities (achieving alphabet, word and sentences), which were based on the learning performance in the game-based achievement learning system.

4.2 Procedure and Data Analysis

An experiment was conducted for a total of ten sessions (two sessions per week for a total of 5 weeks) in two classrooms, totaling 400 minutes. The procedure of this study consisted of three steps and was the same for both classrooms. Firstly, participants were given brief instructions on how to operate the digital game. In the next step, each

participant was asked to complete the questionnaire items on the innovation game attributes within approximately 15 minutes. Subsequently, all of the participants were required to interact with the game-based English learning units (alphabet, world and sentences learning activities) for 180 minutes (a total of five times in each classroom).
A total of 51 participants answered question 5: "When did you start to play computer games?" Based on this question, and following [11]'s scheme of adopter categorization, adopting games was separated into one of five categories using two parameters of the distribution, the mean, and standard deviation of the year 2010, as shown in Table 3. Rogers further described the five categories as falling into two main groups: earlier adopters (innovator, early adopter, and early majority) and later adopters (late majority and laggards), which are used in this study. The mean and standard deviation year and the categorization of adopters are presented in Table 1.

Table 1. Game adopter categories and their frequency.

Two main categories						
Five adopter categories	Innovators	Early Adopter	Early Majority	Late Majority	Laggards	Total
Number of Participants	27			24		51
Percentage	52.941			47.05		100%
Years	<2006	2009	2010.5	2012.1	2013.6<	

To examine the effect of the innovation attributes on learning performance, a linear regression analysis was used, with the measure of the innovation attributes as the independent variables and that of learning activity as the dependent variables. An independent-samples t-test was conducted to test in perceiving innovation game attributes and learning performance whether any significant differences existed between the early and later adopters.

5. Results

5.1 The effects of learners' perceptions of innovation game attributes on learning performance in a game-based achievement learning system

A linear regression analysis was used, with the measure of innovation game attributes such as relative advantage, complexity, and trialability as the independent variables, and that of learning performance as the dependent variable. The results listed in Table 2 indicate that the innovation game attributes in the game-based achievement learning system are the significant predictor of learning performance ($F[1, 49] = 4.47$, $p < .05$). It was found that the innovation game attributes perceived by the learners significantly predicted their learning performance ($\beta=.30$, $p < .05$).

Table 2. Perceived innovation game attributes on learning performance in a game-based achievement learning system.

Game attributes	Model	SS	Df	MS	F	Sig.
	Regression	33.716	1	33.716	4.47*	.039
	Residual	369.164	49	7.534		
	Total	402.880	50			

5.2 Innovation game attributes perceived by early and late adopters in a game-based achievement learning system

Adopters' perceived innovation game attributes in a game-based achievement learning system consist of relative advantages, complexity and trialability. In Table 3 the results portray that the early adopters had lower mean scores for perceiving the relative advantages, complexity and trialability of the game-based achievement learning system than the late adopters. The t-test results showed that the difference between the early and late adopters for the relative advantage and complexity of the game-based achievement learning system dimension's mean score was respectively significant ($t = -2.2$, $p < .05$) and ($t = -2.2$, $p <.05$). Compared to the early adopters, the late adopters had stronger perceptions of the relative advantages and complexity of the game-based achievement learning system. On the other hand, the difference between the early and late adopters' mean score for the trialability of the game-based achievement learning system dimension was not significant ($t = -2.00$, $p >.05$).

Table 3. Game attributes perceived by early and late adopters in the game-based achievement learning system.

	Adopter Category	N	Mean	SD	t	Sig.(2-tailed)
Relative advantage	Early	27	4.148	.78	-2.2	.031
	Late	24	4.575	.58		
	Adopter Category	N	Mean	SD	t	Sig.(2-tailed)
Complexity	Early	27	4.07	.78	-2.2	.032
	Late	24	4.54	.74		
	Adopter Category	N	Mean	SD	t	Sig.(2-tailed)
Trialability	Early	27	3.88	1.05	-1.96	.051
	Late	24	4.40	.73		

In Table 4, the results portray that the early adopters had lower mean scores for alphabet and word learning than the late adopters. The t-test results showed that the differences between the early and late adopters' mean scores for the total alphabet and word dimensions were significant, at ($t = -2.22$, $p < .05$) and ($t = -2.11$, $p < .05$), respectively. Compared to the early adopters (Mean = 24.83), the late adopters (Mean = 25.00) were more involved in the pursuit of the alphabet performance. However, for the sentence acquisition perspective, the late adopters had lower mean scores than the early adopters. The t-test results showed that the difference between the early and late adopters' mean scores for the total sentences dimension was not significant ($t = .293$, $p > .05$). Compared to the early adopters (Mean = 21.61), the late adopters (Mean = 19.81) were less involved in the pursuit of the sentence performance in the achievement system.

Table 4. Adopter categories in different learning scenarios.

	Adopter Category	N	Mean	SD	t	Sig.(2-tailed)
Total alphabet	Early	27	24.83	.36	-2.22	.026
	Late	24	25.00	.00		
Total word	Early	27	18.53	8.12	-2.11	.034
	Late	24	22.41	4.05		
Total sentences	Early	27	21.61	4.98	1.08	.293
	Late	24	19.81	6.82		

6. Discussion and conclusion

This study explored the influence of perceived innovation game attributes on learning performance. The results of this study indicate that perceived innovation game attributes play a significant role in predicting learning performance. The results of this study support the findings of [12], [14], [17], [18], [19]. This study also explored the relationship between early and late adopters regarding their perceptions of the innovation game attributes and their learning performance. The study results found that late adopters had stronger perceptions of the innovation game attributes than the early adopters. This result supports the same concept proposed by Guillén-Nieto and Aleson-Carbonell [21], whose study investigated the effect of digital games and their learning effectiveness. They found that learners with either more advanced or less game experience (i.e., early or late game adopters) improved their learning performance of intercultural communicative competence accordingly due to a number of conditions, such as the game dimension, instructional content, and perceived educational value. Therefore, we can claim that the proposed game-based achievement learning system dimension with its learning content can diminish between the early and late adopters' experience level. However, Baydas et al. [20] found that learners with more game experience as early game adopters could be more used to the game environment, which may influence their content retention, making their learning performance more effective. This finding is similar to this study's sentence pattern learning context in which the early adopters performed better than the late adopters. The study also found that the later adopters achieved high learning performance in the context of alphabet and word learning patterns. Although the above outcomes indicate that the early game adopters had more advantages than the late game adopters in terms of their learning performance, Zhang et al. [22] disclosed that less experienced learners as late game adopters could pay more attention to learning items and need decreased game system usage complexity. Therefore, educators who want to develop game contexts can focus on the advantages of games, ensure less complex usage, and also consider the intercultural communicative competence due to the game dimension, instructional content, and perceived educational value. One of our limitations was not to consider compatibility and observability due to the low reliability of the items.

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Automatic Extraction of Smart Game Based Learning Design Expertise: An Approach Based on Learning Ontology

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Abstract. Smart Game Based Learning System (SGBLS) design is a complex area. It requires the intervention of multiple actors with specific skills and expertise. Unfortunately, novice game designers who do not have necessary competency inspired from both educational and video games systems cannot successfully create SGBLS. For that, they have to acquire specific skills and expertise in an efficient and active pedagogical manner. To solve this problem, there are several existing techniques, among them learning ontology based on semantic annotation. This technique seems promising as it encourage individual and companies to focus on maintaining and enhancing their knowledge asset by facilitating the knowledge extraction, elicitation and representation processes. The main goals of this article are to (a) extract and represent knowledge related to SGBLSs design and (b) render possible accessibility and transfer of that knowledge to novice actors and further to meet aforementioned challenges.

Keywords: SGBLS, gameplay, automatic knowledge extraction, ontology learning.

1 Introduction

Recent years have seen a continuous growth of the volume of electronic data currently available, knowledge extraction techniques become always more necessary to valorize the huge amounts of data stored in the information systems. Motivated by the goal of extracting SGBLS gameplay design knowledge and make it accessible to novice designer, we use automatic knowledge extraction based on semantic annotation. This allows to: (i) Exploit the considerable increase of freely available data about gameplay design, (ii) Acquire and present knowledge in a machine-readable and machine-interpretable format, (iii) Answer to the growing need of making this knowledge accessible, (iv) Foster opportunities

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of sharing up-to-date data within and across organizations and actors participating in SGBLSs design processes, and (v) promote innovation through organizational learning by capturing expertise knowledge's. This proposal follows the following steps: Problem identification and motivation, definition of the objectives for a solution, design and development, demonstration and validation. This paper is organized as follows: In section 2 we describe the problem's statement and major difficulties to overcome; in section 3 we present works related to expertise and knowledge extraction approaches, automatic knowledge extraction methods as well as works having dealt with eventual tentative of extracting SGBLS gameplay design knowledge; in section 4 we detail the approach of Automatic Extraction of SSGBLS Gameplay Design Expertise by presenting fundamental steps of extraction process. In Section 5 we conclude and outline our future works.

2 Challenges of SGBLS design process

GBLSs are considered as a branch of serious games that deal with applications that have defined learning outcomes to create learning experiences that are individually tailored to students based on their cognitive, affective, and metacognitive states [2]. According to [3], Smart Serious Games are an efficient fusion of smart systems and/or smart technologies and serious games to create personalized learning experiences that are both effective and engaging. Designing a SGBLS is a long process that involves many actors from different fields and skills. These actors (academics or businesses) may belong to different enterprises. They must collaborate to maintain and enhance the competitiveness and to allow production of an efficient SGBLS.

However, actors participating in this process still suffer from many challenges that span all over the design and development cycle. Problems of integrating enough educational outcomes without sacrificing the fun characteristics and problems inherent to the complexity of each step in a SGBLS design process are already well entrenched and critical which require relevant expertise to be resolved.

According to [4], designing smart serious games where fun qualities and serious aspects are integrated and respected requires specific skills and expertise in terms of theoretical and technical knowledge background. Unfortunately, novice game designers who do not have technical and theoretical competency inspired from both educational and video games systems cannot successfully create SGBLS.

For that aim, we shall have an appropriate environment allowing the participating actor to curry out his/her tasks efficiently either alone or collaboratively. The overall system should be enough flexible and able to cope with business domain changes or IT changes. The same system must provide to novice actors relevant assistance accordingly to their skills, tasks and context in order to achieve their jobs effectively. Our future system is based on two major components. The first one is relative to gameplay design process; it presents steps to follow by the game designer [5]. The second one is a full-fledged intelligent tutoring system; it contains four models (gameplay model, game designer model, error model and pedagogical model). The gameplay model presents the set of knowledge to be acquired, actions to be performed and rules to be respected by the game designer. The game designer model presents skills and context of the current actor which can determine the type of system intervention. The error model, presents the set of game designer errors, which are classified in categories. The Pedagogical model determines the teaching methods as well as the way in which the intervention can take place (alert notification, assistance messages, a detailed explanation …).

In this paper we focus on the development of the gameplay model through the extraction and representation of knowledge related to SGBLSs design and especially that of gameplay design.

3 Related work

Over the last decade, due to the considerable increase of freely available data, the extraction of relevant information from structured and unstructured content has encouraged researchers in acquiring expertise knowledge. In this section, we will present expertise knowledge extraction approaches as well as automatic knowledge extraction methods. Alternatively, we will describe eventual attempts among knowledge extraction applied to serious games as well as SGBLS design and we attempt to highlight their respective limitations.

3.1 Knowledge acquisition methods

According to [6], there are five methods that can be used to extract expertise knowledge from human experts; those are respectively method of familiar tasks, method of structured and unstructured interviews, method of constrained processing task and method of tough cases.

Method of familiar tasks: It involves the detailed analysis of the tasks that the expert usually performs. It requires looking across a set of expert's specific tactics and procedures followed in tasks that experts are typically engaged in.

Method of structured and unstructured interviews: Interviews are a widely used tool to access people's experiences and their inner perceptions and attitudes. This method consists on querying the expert by a knowledge engineer while the expert is performing or talking about familiar task.

Method of limited information tasks: A familiar task is performed but the expert is not given certain information that is typically available. This method is especially useful for revealing expert's strategies.

Method of constrained processing task: A familiar task is performed but the expert must do so under time or other constraints. It facilitates the identification of attempts to constrain or alter the reasoning strategies that the expert uses.

Method of tough cases: This method consists on subtle or refined aspects of an expert's reasoning are often manifested when an expert encounters a tough case, a case with unusual, unfamiliar or challenging features.

The shortcomings of these methods are that they:

- Provide imperfect results if they are applied separately.
- Provide data with non standardized format. This requires further analyses and transcription.
- Are based on a single expert which can result a single line of reasoning that makes it difficult to evoke in depth discussions of the domain. Moreover, not all expert knowledge resides with the single expert. And therefore, these methods might not actually be very informative about the expert's reasoning.

3.2 Automatic knowledge Extraction Methods

To overcome limits of methods cited in section 3.1, automatic knowledge extraction seems very promising since it allows to:

- Exploit the considerable increase of freely available data.
- Discover relevant information from structured and unstructured sources.
- Acquire knowledge in a machine-readable and machine-interpretable format.

In this context, the use of learning ontology techniques can facilitate not only knowledge extraction and elicitation processes, but also grants more formal knowledge representation which allows to answer to the growing need of sharing data within and across organizations and actors. Learning Ontology, also called ontology population and enrichment, is the task of extending an existing ontology with additional objects as instances, concepts and semantic relations. This task is considered as a knowledge acquisition task [7]. The process of constructing, enriching and populating ontology is considered as resource demanding and time-consuming. Thus, the automated or semi-automated construction, enrichment and population of ontologies are highly desired.

In [8] authors propose an incremental process to populate ontology, including 4 tasks: First, The ontology-based Semantic Annotation task: The instances of the domain ontology are used to semantically annotate a domain-specific corpus in an automatic way. In this stage disambiguation techniques are used exploiting knowledge captured in the domain ontology. Second, the knowledge Discovery task: An information extraction module is used in this stage to locate new ontological instances. The module is trained, using machine learning methods, on the annotated corpus of the previous steps. Third, the knowledge Refinement: A compression-based clustering algorithm is used in this step for identifying lexicographic variants for each instance supporting the ontology enrichment. And finally the validation and Insertion task: A domain expert validates the candidate instances that have been added to the ontology.

This process demands human intervention to validate and insert extracted entities, which constitutes a very time consuming and error prone task. In [9] authors, decompose the ontology learning process into six steps . Starting by identifying terms (objects), then defining synonyms terms, thereafter selecting concepts and defining hierarchies and finally establishing relations and acquiring rules. This process neglects an important task related to redundancy detection, which constitutes the major defect of this approach. Authors in [7] consider that the ontology learning process involves population, enrichment, and inconsistency resolution steps. Indeed, an initial ontology is used to analyze and extract information from a corpus. The extracted information is used to populate and enrich the ontology. This process continues until no more information can be extracted from the corpus. In every cycle the consistency of the ontology is checked and redundancy problems are detected.

3.3 Knowledge Extraction Methods Applied on SGBLS Design

Authors in [10] present an overall classification system for Serious Games. The intention of this classification is to guide people through the vast field of Serious Games by providing them with a general overview. For that aim, authors present a G/P/S model (Gameplay/Purpose/Scope model) that propose a classification based on gameplay, purpose and scope criteria of the game. Authors have built a collaborative online database. This database assembles the classification information about 550 Serious Games. The G/P/S model it is not able to provide detailed information concerning serious games design knowledge which constitutes its main limitation. In a similar approach [11], [12] and [13] propose classification systems to index games according to the “markets” that use them (i.e. the kind of people who play them).

Proposed solutions are not able to provide detailed information concerning Serious Games. It can only differentiate between games according to a limit number of criteria (target audience, purpose,...). These limits restrict the general use of this system to respond to SGBLS designer’s requirements. Additionally, they are based on the applications of Serious Games rather than on the games Design process.

To conclude, we did not find any research work that aims to extract automatically SGBLSs design knowledge, and present that knowledge through a concrete and semantic model.

At the best of our knowledge, there are no works based on semantic web technologies to automatically extract information specific to SGBLS from texts and to give a structured organization to such knowledge.

In order to reap the full benefits of automatic knowledge extraction techniques, we opt to use learning ontology technique. In the present paper, we will focus on the enrichment and the population of the SGBLS gameplay ontology developed in [14] to:

- Entail the semantic description of the concepts related to SGBLS gameplay design process.
- Present the set of experts' knowledge about gameplay design.
- Specify the knowledge about tasks to be performed when designing SGBLS.
- Make SGBLS design environment auto-adaptable to face endless change of conceptual, strategic and procedural knowledge.
- Capture the collective expertise and intelligence and use them to promote innovation through an organizational learning.
- Present the set of knowledge that the novice game designers have to acquire.

4 Automatic Extraction of SGBLS Gameplay Design Expertise

4.1 SGBLS gameplay design competencies

Helping beginners to acquire a new set of competencies related to SGBLS gameplay design consists on acquiring a set of fundamental competencies which are applied on three axes: The first axe includes attitudes: which present the work methods, they determine not only the sequence of steps to follow but also capability of adapting their approach to the project problems, the communication and coordination with the SGBLS design team. The second axe concerns skills related to manipulating new technologies. The final axe concerns Knowledge that includes three main types [15] as conceptual knowledge, procedural knowledge and strategic knowledge.

Conceptual knowledge: presents different static knowledge about facts and concepts related to SGBLS gameplay design. Procedural knowledge: includes the set of operations that can be applied on concepts to make transition from one problem state to another. The final type of knowledge concerns the capability that enables game designer to combine its procedural and conceptual knowledge with change adaptation. It can be seen as a general plan of actions in which the sequence of solutions activities is laid down. It concerns knowing how to organize and interpret the information given.

The Automatic Extraction of Gameplay Design Expertise focuses on collecting conceptual knowledge of SGBLS gameplay design. Indeed, as the SGBLS gameplay design was presented through ontology [14], enrichment and population of this ontology with information extracted from various resources in automatic way is a pertinent solution. It's giving the opportunity to exploit web resources of gameplay that contains necessary knowledge to be acquired.

4.2 SGBLS Gameplay Ontology Population and Enrichment

The attraction of using a semantic technology, to address the problem of gameplay modeling, lies in its potential to associate a semantic network of knowledge related to gameplay description. These descriptions can then be exploited to add new instances, concepts, relations and rules to the gameplay ontology, providing the developer with new ways and knowledge to design SGBLS gameplay. Two fundamental tasks are addressed to obtain the aforementioned goals, the semantic annotation and the Ontology Learning.

In fact, gameplay descriptions come from multiple resources such as those presented in game instructions, descriptions, and presentation or in GDDs (Game Design Documents).

For this end, four tasks can be identified. The first task concerns initial ontology building. The second task is related to the addition of new instances of concepts/relations into the initial ontology to produce the populated ontology, usually by locating the corresponding object/terms and synonyms in the corpus. The third task is the consistency resolution; it is the responsible for remedying problems introduced by population and enrichment to obtain the consistent ontology. After that, the obtained ontology is exported as RDF file and finally, performance evaluation can be calculated.

Corpus construction. The corpus is composed of SGBLS gameplay descriptions collected from many resources as game instructions presented in social network e.g facebook, Game Design Documents….For that aim, we select SGBLS designed in different periods to limit the impact of technological change on the results that may be obtained. Also, we choose SGBLS with single players and SGBLS with graphical outputs.

Initial gameplay ontology. The formal representation of concepts, relationships and instances are described in ontology named initial ontology. Many methodologies are used to design ontology (i.e., [16] [17] and [18]). All of them consider basically the following steps: definition of the ontology purpose, conceptualization, formalization, and validation. The SGBLS gameplay ontology is built according to steps aforementioned; it is presented in our previous work [14].

Ontology population. Ontology population requires (i) an initial ontology that will be populated by inserting concepts and relations, and (ii) an instance extraction engine. For this end we use the information extraction toolkit GATE [18] which performs named entity recognition, syntactic and semantic analysis [20]. The extracted concepts and relations are used to populate the SGBLS gameplay ontology. The result is an annotated corpus. The structure of ontology does not change throw ontology population, the concept hierarchy and relations are not modified. What changes is the set of instances of concepts and relations in the domain. The annotated corpuses as well as the ontology population are depicted in Fig. 1.

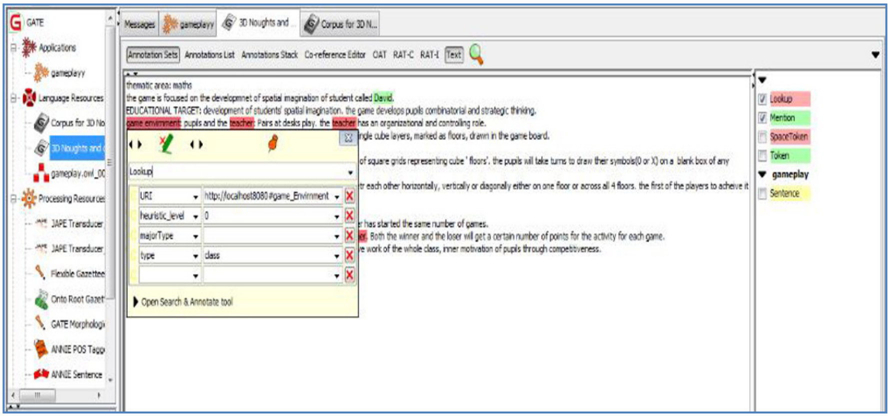

Fig.1. Example of annotated corpus using the gameplay ontology

Inconsistency resolution. This key process constitutes aims to maintain the consistency of the ontology and to eliminate redundancies. Consistency maintenance and redundancy elimination are both automated processes. The first one can be performed with the help of WSMO [21], while redundancy elimination is performed by adding word net plugin in GATE toolkit.

Performance Evaluation. Information extraction adopts the typical evaluation measures for text classification tasks being recall and precision, their combination into the Fmeasure, and accuracy. The effectiveness of automatic assignment of the semantic classes is directly computed by comparing the results of the automatic assignment with the manual assignments by an expert [22]. Recall (R) is the proportion of class members that the system assigns to the class. Precision (P) is the proportion of members assigned to the class that really are class members. Fallout (Fal) computes the proportion of incorrect class members given the number of incorrect class members that the system could generate. In our case, recall and precision are close to 1 and fallout is close to 0.

5 Conclusion and future work

The current work has presented an approach to define SGBLS gameplay design knowledge. The idea is to help novice game designer by giving them the opportunity to access, acquire, exploit and share expertise knowledge to produce more attractive and efficient SGBLSs. The proposed approach has been based on a learning ontology proposal focused on enriching and populating ontology with new concepts, instances and relationships related to SGBLS Gameplay design expertise. The obtained ontology includes the definition of axioms and rules that are useful to reason or infer new information promoting learning purposes or sharing up-to-date data within and across organizations and actors participating in SGBLSs design processes.

Our future work will consist on integrating the obtained ontology to the SGBLS design frame work that will assist novice game designer through an assistance system where the populated ontology constitutes its expert domain model.

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A Study On Two Hint-level Policies in Conversational Intelligent Tutoring Systems

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Abstract. In this work, we compared two hint-level instructional strategies, minimum scaffolding vs. maximum scaffolding, in the context of conversational intelligent tutoring systems (ITSs). The two strategies are called policies because they have a clear bias, as detailed in the paper. To this end, we conducted a randomized controlled trial experiment with two conditions corresponding to two versions of the same underlying state-of-the-art conversational ITS, i.e. DeepTutor. Each version implemented one of the two hint-level strategies. Experimental data analysis revealed that pre-post learning gains were significant in both conditions. We also learned that, in general, students need more than just a minimally informative hint in order to infer the next steps in the solution to a challenging problem; this is the case in the context of a problem selection strategy that picks challenging problems for students to work on.

Keywords: macro-adaptation, intelligent tutoring systems, assessment

1 Introduction

A key ingredient in tutoring is the use of effective instructional strategies. Accordingly, discovering and validating effective instructional strategies has been a key research goal in this area undertaken by many researchers (Aleven, Popescu, & Koedinger, 2001; Cade, Copeland, Person, & D'Mello, 2008; Jeong, Gupta, Roscoe, Wagster, Biswas, & Schwartz, 2008; Rowe, Mott, McQuiggan, Robison, Lee, & Lester, 2009).

The quest for effective strategies is even more critical and challenging given that average human tutors rarely enact sophisticated tutoring strategies (Graesser, D'Mello, & Person, 2009). Therefore, there is a need to discover and understand effective tutoring strategies that are either manifested by expert tutors or are motivated by pedagogical theory. In the latter case, the approach is to design theory-based strategies, implement them in an ITS, and then conducting experiments to validate them. We adopt this approach in our work, which complements a category of approaches that discover strategies from expert tutors' sessions through data mining (DiEugenio, Kershaw, Lu, Corrigan-Halpern, & Ohlsson, 2006; Cade et al., 2008; Boyer, Phillips, Ingram, Ha, Wallis, Vouk, & Lester, 2011; Rus, Maharjan, & Banjade, 2015). An important challenge of the latter approaches is that tutoring expertise is yet to be elucidated (Rus, Maharjan, & Banjade, 2015).

Broadly speaking, ITSs implement two levels of instructional strategies corresponding to the two major levels of adaptivity, macro- and micro-adaptivity (VanLehn,

E. Popescu et al. (eds.), *Innovations in Smart Learning*,
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2006), although adaptivity in ITSs is more complex (Rus, Conley & Graesser, 2014; Rus & Stefanescu, 2015). *Macro-adaptivity* refers to a system's ability to select appropriate instructional tasks for the learner to work on. *Micro-adaptivity* describes an ITS's ability to adapt its strategies while a learner is working on a particular instructional task (hence, also called within-task adaptation).

In order to properly characterize micro- and macro-adaptation in ITSs, we adopt the terminology introduced by Rus, Graesser, and Conley (2014) who distinguish between strategies, tactics, and policies. Accordingly, tactics are pointwise/local decisions regarding the next move that the tutor can take at any tutor-turn in the learner-tutor interaction (VanLehn, Jordan, & Litman, 2007). Examples of such tactics are eliciting or telling an important piece of information necessary to accomplish the current instructional task. A strategy defines the space of possible sequences of tactical decisions or pedagogical moves. Importantly, any sequence of such tactical decisions in this space of possible sequences could be enacted by the ITS. If the sequence has n moves then the space will have 2^n possible sequences if for each move there are two potential values: tell or elicit. If we regard a sequence of tutor moves a *plan of action* then a strategy defines the space of possible plans of action.

A strategy can have an explicitly pre-set bias, e.g. elicit a step in a solution to a problem if the student has not yet articulated it (Rus, Conley, & Graesser, 2014). According to Rus, Graesser, and Conley (2014), such strategies with a clear bias are called policies. It is important to distinguish between strategies and policies as strategies define the space of possible sequences of actions given the set of available tactics while policies denote a subset of this space; the subset is determined by the bias in policy. When a policy is implemented in an ITS, the tutoring system will dynamically select at run-time a sequence of actions from the subspace defined by the policy. The advantages of having policies is that they can be derived from theories of learning among other things, as explained later.

In our work, we experimented with and validated two such biased strategies, i.e. policies, at micro-adaptivity level in the context of a state-of-the-art conversational ITS, called DeepTutor (www.deeptutor.org; Rus, D'Mello, Hu, & Graesser, 2013). Problem-solving is the primary instructional activity.

We distinguish between two levels of micro-adaptivity: step-level versus hint level. Step-level adaptivity implies strategies that may involve, for instance, eliciting, telling, or entirely skipping a particular step in the solution to a problem. Hint-level adaptivity is about the ability of an ITS to adapt its sequence of pedagogical moves while the students are focusing on a particular step of the solution to, say, a Physics problem. At this hint-level of adaptivity, the tactical decisions are whether to give a hint (or not) meant to help the student think about and articulate the current (or part of the current) step in the solution to the problem. Indeed, the focus of the paper is on comparing two such hint-level policies. The two hint-level policies are *maximum scaffolding* and *minimal scaffolding*. The maximum scaffolding policy has the bias of "always give the next available hint for a step", i.e. offer maximum support. The minimum scaffolding policy has the bias of "give only a minimum level of hints" for a given step; this policy provides students with a minimally informative and, if needed, the bottom-out hint. More details about these two strategies are offered later in the paper.

In order to assess and understand the effectiveness of these two hint-level policies in dialogue-based ITSs, we conducted a randomized controlled trial experiment with two conditions corresponding to two ITSs, each implementing one and only one of the two policies. It should be noted that the two policies were implemented in the same state-of-the-art conversational ITS resulting in two versions of the same ITSs, DeepTutor (Rus, D'Mello, Hu, & Graesser, 2013), that are identical in all respects except the hint-level strategies. A typical tutoring session consists of a set of problems that learners are asked to solve and, if needed, help is being offered by the ITSs through scaffolding dialogue. The target domain was conceptual Newtonian Physics and the target population was college students in nursing and engineering taking an introductory course in Physics. We report results of our experiment and discuss implications of the results as well as avenues for future work.

2 Related Work

The ITSs community has been diligently working towards discovering patterns of tutor/instructor actions, i.e. strategies, that are effective. A widely adopted approach to discovering effective strategies is to understand (through manual analysis or data mining tools) what expert tutors do, a research goal undertaken by theoreticians and empiricist alike (Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; DiEugenio et al., 2006; Cade et al., 2008; Jeong et al., 2008; Boyer et al., 2011; Lehman, D'Mello, Cade, & Person, 2012). There are two caveats of this approach: (a) tutoring expertise is yet to be elucidated and (b) effective tutoring (the kind that induces learning gains) is not always equivalent to expert tutoring (do the right thing). For instance, in some cases tutoring expertise is measured by years of experience or how much a tutor is paid, which are rough proxies of expertise. As a case in point, (human) tutors may seem more expert than they actually are if, for instance, they are very selective when it comes to their students, e.g. they may choose to work only with high-ability and highly-motivated students. On the other hand, a tutor who applies sound tutoring strategies may seem less of an expert and less effective if working with a group of students who are low in ability and/or lack motivation. Our work complements these learning-from-expert-tutors approaches to discovering effective tutorial strategies.

We adopted a design-and-experimentation approach which means we design strategies based on theory and then validate the strategies through experimentation. If the validation succeeds there is reason to believe that the strategies are effective. Our approach is similar to the one in Graesser et al. (2001) and Aleven, Popescu, and Koedinger (2001) who validated strategies by implementing them in a computer tutor and then showing their effectiveness through experimentation. For instance, Graesser and colleagues (2001) experimented with a strategy in which the next step in a solution to a problem is selected from the pool of yet uncovered steps using a zone of proximal development (ZPD) principle, i.e. a student is prompted to work next on an uncovered step which has the highest semantic proximity to previous student responses. Note that their focus is on step-level strategies as opposed to hint-level strategies in our case. Furthermore, this ZPD-based strategy is in fact a policy because "always select the next most-similar step if not articulated yet by the student" is a well-defined policy in their ITSs. It is important to emphasize that a policy does not mean lack of individual tailored instruction. For instance, if a student articulated a particular step by herself, that step will never be elicited by the ZPD policy; if another student did not articulate the step, the ZPD policy would elicit the step. In a similar vein, VanLehn, Jordan, and Lipman (2007) and later Chi, VanLehn, Litman, and Jordan, (2011) explored the space of strategies defined by a set of tactics (such as elicit or tell a step) in order to learn a policy function using reinforcement learning techniques.

It should be noted that the above prior work focused on micro-adaptive strategies. Macro-adaptive strategies in ITSs have been explored as well (Rus, Stefanescu, Baggett, Niraula, Franceschetti, & Graesser, 2014; Doignon & Falmagne, 1999). Due to space reasons, we do not elaborate further prior work on macro-adaptive strategies.

We would like to add that the present study contributes to the important research goal of understanding which macro- and micro-level strategies work and interact best. It holds the promise of furthering our understanding of the tutoring process and providing an answer to the ardent question of how to improve the effectiveness of tutoring beyond the interactivity plateau (VanLehn, 2011).

3 Adaptation in ITSs Using Strategies, Policies, and Tactics

As already mentioned, in order to conceptualize our work we adopted the instructional framework proposed by Rus, Conley, and Graesser (2014) who distinguish among strategies at various instruction granularity levels: curriculum/standard level, course level, lesson/session level, instructional task/activity level, step level, and hint-level. That is, we can identify strategies, policies, and tactics at each of those levels of instructions. As already mentioned, we focus in this work on policies at hint-level. Adopting such pre-set policies has several advantages: (1) they could be based on theoretical foundations such as the fact that self-explanation is beneficial to learning; therefore, promoting a habit of self-explanation through the adoption of a tutorial policy that "always asks for a self-explanation" could have long-lasting benefits for the learner; (2) they could be implemented in ITSs and validated through experimentation; and (3) they are interpretable as opposed to policies inferred through data-mining which are hard, if not impossible, to interpret. We present next the hint-level component of our intelligent tutoring system in order to better illustrate the role of strategies/policies at this level.

Hint-level Policies In DeepTutor

In our intelligent tutoring system DeepTutor, during a tutorial session students are given a set of Physics problems to solve, one at a time. Students are asked to provide first a complete solution which must include a justification based on Physics concepts and principles. Students are encouraged (or, better said, gently pushed) through hints in the form of questions to self-explain their solutions while solving the assigned Physics problems. It should be noted that the pedagogical approach in DeepTutor follows constructivist theories of learning according to which learners construct their own knowledge. For that reason, students are encouraged to discover the complete and correct solution to the Physics problems by themselves; help is only provided when students flounder, as explained next.

It is often the case that students provide incomplete or incorrect solutions to a given problem and therefore the dialogue-based ITS initiates a scaffolding dialogue to help students discover the solution. A subgoal in the scaffolding dialogue is to help students articulate missing logical steps in the solution. Correcting a student-articulated misconception is another scaffolding subgoal, for instance. When focusing on a particular missing step, the scaffolding consists of a sequence of hints meant to help the student think about the step. This sequence of hints typically starts with a minimally informative hint, i.e. a vague hint, and ends with a bottom-out hint in the form of a fill-in-the-blank question. That is, the general instructional strategy is self-explanation constructivist scaffolding, including at hint level, the focus of this paper. It is based on self-explanation and constructivist theories of learning. The two hint-level strategies we focused on have their own biases, as explained earlier, and therefore are policies.

The major difference between the two hint-level policies we investigated is the set of hints available to use when needed. For *minimal scaffolding*, there are only two hints available: a first minimally informative hint and a bottom-out hint (fill-in-the-blank hint). For *maximum scaffolding*, the set of available hints include all possible hints as allowed by the domain constraints – see the *Cognitive Task Analysis* subsection for further details. It is important to note that the set of available hints for a step is just that: a set of available hints, which may or may not be used up for a particular student during tutoring. Indeed, if a student articulates the targeted step after receiving a particular hint, the rest of the hints are not needed/triggered anymore. This is true for both the minimal and maximal hint-level scaffolding policies. Also, given that in the minimum scaffolding case there are only two extreme hints available (the minimally informative and the bottom-out hint), the conceptual distance between the two consecutive hints is larger than between two consecutive hints in the maximum scaffolding case. This conceptual distance between consecutive hints is a major difference between the two policies.

Cognitive Task Analysis

We detail in this subsection how we designed hints for the logical steps in a solution to a (Physics) problem. This design process consists of a detailed, in-depth cognitive task analysis driven by learning theory and domain constraints.

Based on constructivist theories of learning, hints are so designed to encourage students articulate the logical steps of a solution to a problem by themselves with minimal help from the tutor, i.e. the tutor should only provide support when needed – not more, not less. Therefore, for each step in a solution we designed a sequence of progressive hints (targeting a step) with a first hint in the sequence being least informative (*Which Physics law is most relevant to this situation?*) and the final or bottom-out hint being most informative in the form of a fill-in-the-blank question (*The rocket will move in a* ______ *line.*; correct answer is *straight*). Students will see the bottom-out hint if all previous hints failed to stimulate them to think about and articulate the target step. It should be noted that we avoided generic/informationless hints such as *What else?*, called pumps in previous work, because we learned that they frustrated students at all knowledge levels: low knowledge students do not have enough knowledge to be able to respond to a hint like *What else?*, while high knowledge students do not benefit from such a generic hint because in their case they don't know what else is expected (they already articulated much of what they know).

We also had to consider domain or topic-related constraints when designing the set of hints for a step in the solution to a problem. For instance, some steps in a solution could be broken down into substeps and therefore hints for each of these substeps could be designed. An example of such a decomposition of a more complex step into substeps is the following: *The meteor will move with constant velocity in a straight line*. This step has two atomic substeps: "*the motion is in a straight line*" and "*the motion is with constant velocity*." However, other complex steps could not be decomposed easily in such meaningful substeps without losing important information. For instance, when students are asked to articulate Newton's second law, *force equals mass times acceleration*, breaking this step into substeps, each focusing on the relation between each pair of these concepts (force and mass, mass and acceleration, or force and acceleration), is not recommended because it will lead to obscuring the important three-way relation at the heart of Newton's second law: the three-way relation between force, mass, and acceleration, which is force equals mass times acceleration (F = m • a).

Instructional Strategies At Other Levels of Instruction

While our focus is on hint-level strategies, it is important to specify the set of strategies at all levels of instruction that were implemented in the underlying intelligent tutoring system. Specifying all the strategies at all levels is important because they all impact students' learning as suggested by Rus, Graesser, & Conley (2014). In our case, all levels of instruction above session level (curriculum/standard level, course level) were controlled by the college instructor who was teaching the course that our subjects attended and therefore were beyond our control. For instance, the instructor decided what topics to be covered and in which order, the pace of covering those topics, etc. We aligned the content of our ITS with the instructors' content at these higher levels of instruction.

At session level, we adopted the following task selection strategy: the instructional tasks (i.e. conceptual Physics problems) were selected using a data-driven approach based on the highest potential learning gains, i.e. they corresponded to concepts on which our cohort of students received the lowest scores on the pretest. One could argue that those tasks are the hardest for our students – in a way, we may call this an "iron-pumping" task selection policy. At solution level, the following strategy was implemented: the steps in a solution to a problem were ordered using a pre-defined problem solving strategy (identify first the relevant Physics principles for the current task and then apply them to infer the answer) as opposed to, for instance, the Zone-of-Proximal-Development (ZPD) strategy of Graesser and colleagues (2001). Within a step, the hint selection strategies (minimum versus maximum scaffolding), the focus of this study, are described in detail throughout the paper.

4 Experiment and Results

The goal of the experiment was to understand and investigate the effectiveness of the two hint-level policies, minimum and maximum scaffolding, in conversational ITSs through a randomized controlled trial experiment.

Subjects. Students attending a conceptual Physics course at a U.S. university were recruited for this experiment. This was an introductory course opened to all college students and which is typically attended mostly by non-Physics and non-STEM (Science, Technology, Engineering, and Mathematics) students (e.g., nursing students) although STEM students (e.g. engineering or chemistry majors) take it in a smaller proportion. The course provided the pre-requisite kind of training that seems to be important for experiments of the type we are describing here. Subjects were randomly assigned to one of the two training conditions: maximum vs. minimum scaffolding.

Condition 1 (MaxScaffolding). In this condition, students interacted with one version of the state-of-the-art dialogue-based ITS DeepTutor that implemented the maximum scaffolding policy for hints.

Condition 2 (MinScaffolding): In this condition, students interacted with one version of the same ITS, DeepTutor, that implemented the minimum scaffolding policy.

Procedure. After they took a pre-test, students were given the opportunity to sign up for free tutoring sessions. Students who chose to participate were given extra credit in the course. Each student individually interacted with the tutoring system on a personal computer in a computer lab. Each training session was about 1.5-hour long and consisted of approximately 1-hour of computer-based tutoring (9 Physics problems) followed by a 0.5-hour post-test. Pre-test and post-test were identical. Students took the pre-test approximately one week before the actual training in order to mitigate tiring effects during the actual training session and to handle logistical constraints. The pre/post-test consisted of 39 multiple choice questions: 24 multiple-choice questions from the Force Concept Inventory (FCI; Hestenes, Wells, & Swackhamer, 1992), 8 multiple-choice questions about force and motion (Alonzo & Steedle, 2009), and 7 multiple-choice questions of our own (total=39 questions). We eliminated some of the FCI questions that were not directly related to the Physics topics we targeted.

Results. There were 41 students who participated in the experiment, with 21 of them in the MinScaffolding condition and 20 of them in the MaxScaffolding condition. However, we had complete data for only 19 students in the MinScaffolding condition and 17 students in the MaxScaffolding condition. There was no significant difference in pre-test scores (percentage correct on the test) between the two conditions, with means of .50 and .43 in the MinScaffolding and MaxScaffolding conditions, respectively, ($t(34)=1.39$, $p=.174$). There also was no significant difference between the two conditions for post-test scores, means of .63 and .57, respectively, $t(34)=.893$, $p=.378$. A mixed ANOVA analysis was conducted with a pre-post test within-subjects variable and the condition as a between-subjects variable. The ANOVA revealed that there was no significant test*condition interaction ($F(1,34)=.991$; $p=0.329$). There were learning gains in both conditions. A pre-post test comparison revealed that the minimum scaffolding condition had a Cohen's effect size of $d= 0.907$ (computed using means and pooled standard deviations) and the maximum scaffolding condition had an effect size of $d=0.747$. This effect size is as good as human tutors if we assume VanLehn's (2011) reported average human tutor effectiveness of d= 0.79 (across many domains).

Given that a major difference between the two conditions was the number of potential hints a students may get, we compared the number of bottom-out hints students received on average for the whole session. If a student received a bottom-out hint, that would be an indication that the student received all available hints for that particular step. Students in the minimum scaffolding condition received significantly (t(34)=2.125, p=0.040) more bottom-out hints (average=13.14 for the whole session, stdev=4.829) than students in the maximum scaffolding condition (average=9.75, stdev=5.388). The maximum number of bottom-out hints possible for the 9 problems in our experiment was 36, for an average of 4 per problem.

We also compared the total number of hints students received in the minScaffolding condition (average=5.91) versus the maxScaffolding condition (average=6.66) and found no significant difference (t(34)=-1.370, p=.180). That is, students in the minScaffolding condition receive a similar number of hints per problem but more of these are bottom-out hints. In general, students in the minScaffolding conditions receive a first minimally informative hint and the only next available bottom-out hint while students in the maxScaffolding condition receive the first minimally informative hint and then intermediate hints without necessarily reaching the bottom-out hint. The conclusion is that students need more than just one minimally informative hint to articulate a step (when they need scaffolding for that step). The bottom-out hint and an intermediate hint seem to work similarly well (given that the learning gains were similar) although further analyses are needed to fully validate this claim.

In our experiment, the need for more than one hint for a step could be a consequence of our task-selection strategy: we chose problems related to concepts with the highest potential learning gains, i.e. concepts students showed least mastery for in the pre-test (were the most challenging or hardest). One could therefore argue that for these hardest concepts students need more help with, i.e. more than the first, minimally-informative hint for a given step.

The above findings are also consistent with another finding: students in the maximum scaffolding condition generated more words. Indeed, the overall student word production was significantly different between the two conditions (t=-2.039; p=0.048). The average token production per problem for students in the minimum scaffolding condition was 124.28 (total for all 9 problems; stdev=59.97) versus 165.00 (stdev=67.77) in the maximum scaffolding condition. This is not surprising given that the students in the maximum scaffolding condition were prompted to talk more through the number and type of hints. When receiving bottom-out hints, which is more the case in the minimum scaffolding condition, students only need to reply with one or two words to fill-in the blanks while students who received a second or even a third intermediate hint are expected and usually respond with a more elaborate answer. One could argue that more word generation implies a more intense self-explanation process and therefore students in the maximum scaffolding condition should have learned more. This is indeed something to explore further. For instance, we may not observe such an effect because of not enough power, i.e. the low number of subjects in the experiment.

5 Conclusions

Our study revealed no significant difference in learning between the minimum hint-level scaffolding and the maximum hint-level scaffolding policies. In a way that was expected and confirms our original hypothesis that students with a critical mass of knowledge (pre-test scores were at reasonable levels for all students, i.e. close to .50 as a percentage of correct responses in the pre-test) should do well with a minimum number of hints. The advantage of the minimum hint policy is a more efficient and streamlined tutorial session, i.e. students could go through the same number of problems in less time, which might eliminate fatigue effects and disengagement by the end of a long session. The minimum scaffolding students finished all 9 problems in 43 minutes, on average, while maximum scaffolding students needed 53 minutes, a significant difference ($t=2.776$, $p=0.008$). It should be noted that the longer sessions in the maximum scaffolding conditions were not just slower, i.e. students were not just taking more time to respond. They were prompted to talk more by the nature of the hints they received, as explained earlier.

Our findings with respect to the hint-level strategies should be interpreted in the context of other instructional strategies implemented at the other levels of instruction in our ITS. For instance, the finding that students need more than one hint per step need be interpreted in the context of the task-selection strategy we used: select problems targeting concepts with highest potential learning gains. For such challenging problems, for the missing steps in the solution students need more help.

Furthermore, our results should be interpreted while accounting for students' prior-knowledge which in our case, for both conditions, was robust. We wonder if the two hint-level strategies would lead to similar learning gains for students with significantly lower prior knowledge. This is something to explore in the future.

Our work here is part of our longer term goals to fully understand strategies and interactions among strategies at all levels of instruction.

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Dialogue Act Classification In Human-to-Human Tutorial Dialogues

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Abstract. We present in this paper preliminary results with dialogue act classification in human-to-human tutorial dialogues. Dialogue acts are ways to characterize the actions of tutors and students based on the language-as-action theory. This work serves our larger goal of identifying patterns of tutors' actions, in the form of dialogue acts, that relate to learning. The preliminary results we obtained for dialogue act classification using a machine learning approach are promising.

Keywords: macro-adaptation, intelligent tutoring systems, assessment

1 Introduction

A key research question in intelligent tutoring systems (Rus, D'Mello, Hu, & Graesser, 2013) and in the broader instructional research community is understanding what expert tutors do. This goal is motivated by research showing that expert tutors are more effective when it comes to student learning gains (2-sigma effect size which is equivalent to 2 letter grades improvement, e.g. from C to A) than unaccomplished tutors (effect size=0.4; Bloom, 1984).

A typical operationalization of this goal of understanding of what good tutors do was to define the behavior of tutors based on their actions. In our case, we model the dialogues as dialogue-act sequences because there are no other types of actions, e.g. task actions as in Boyer and colleagues (2011), that are available in the human-to-human tutorial dialogues we obtained.

Our view of a tutorial dialogue as a sequence of actions is based on the language-as-action theory (Austin, 1962; Searle, 1969) according to which when "we say something, we do something." Therefore, all utterances in a tutorial dialogue are mapped into corresponding dialogue acts using, in our case, a predefined dialogue or speech act taxonomy. The taxonomy was defined by educational experts and resulted in a two-level hierarchy of 16 top-level dialogue acts and a number of dialogue subacts. The exact number of subacts differs from dialogue act to dialogue act. The overall, two-level taxonomy consists of 140 unique dialogue-act-subact combinations. It should be noted that automatically discovered dialogue act taxonomies are currently being built (Rus, Graesser, Moldovan, & Niraula, 2012) but it is beyond the scope of this paper to automatically discover the dialogue acts in our tutoring sessions.

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2 The Approach

We adopted a supervised machine learning method to automate the process of dialogue act classification. Machine learning methods imply the design of a feature set which can then be used together with various machine learning algorithms such as Naive Bayes, Decision Trees, and Bayes Nets. In the automated dialogue act classification literature, researchers have considered rich feature sets that include the actual words (possibly lemmatized or stemmed) and n-grams (sequences of consecutive words). In almost every such case, researchers apply feature selection methods because considering all the words might lead to overfitting and, in the case of n-grams, to data sparseness problems because of the exponential increase in the number of feature values. Besides the computational challenges posed by such feature-rich methods, it is not clear whether there is need for so many features to solve the problem of dialogue act classification.

We believe that humans infer speakers' intentions after hearing only few of the leading words of an utterance (Moldovan, Rus, & Graesser, 2011). One argument in favor of this assumption is the evidence that hearers start responding immediately (within milliseconds) or sometimes before speakers finish their utterances (Jurafsky and Martin 2009 - pp.814).

Intuitively, the first few words of a dialog utterance are very informative of that utterance's dialogue act. We could even show that some categories follow certain patterns. For instance, Questions usually begin with a *wh-* word while dialogue acts such as Answers, Accepting, or Rejecting, contain a semantic equivalent of *yes* or *no* among the first words, and Greetings use a relatively small, i.e. almost closed, set of words and expressions. In the case of other classes, distinguishing the dialogue act after just the first few words is not trivial, but possible. It should be noted that in typed or chat-based dialogue, which is a variation of spoken dialogue, some information is lost. For instance, humans also use spoken language indicators such as intonation to identify the dialogue act of a spoken utterance. We must also recognize that the set of indicators allowing humans to classify the dialogue act of an utterance also include expectations created by previous dialogue acts (previous context), which are discourse patterns learned naturally. For instance, after a first Greeting another Greeting, that replies to the first one, is more likely. We ignored such intonational and contextual clues so far in our work in order to explore the potential of classifying dialogue acts based on the utterance alone. We do plan to incorporate contextual clues in future experiments.

3 The Taxonomy

The dialogue act taxonomy that we used in this work builds on a previously proposed taxonomy (Morrison, Nye, Samei, Datla, Kelly, & Rus, 2014). The new taxonomy, which is a refined and extended version of the one proposed by Morrison and colleagues, is considerably more granular than previous schemes (Boyer et al., 2011).

The most recent version of the taxonomy employs two levels of descriptions. At the top level, it identifies 16 standard dialogue act categories including Questions, Answers, Assertions, Clarifications, Confirmations, Corrections, Directives, Explanations, Promises, Suggestions, and so forth. It also includes two categories, Prompts and Hints, that have particular pedagogical purposes. Within each of these major dialogue act categories there are between 4 and 22 subcategories. For example, we distinguish Assertions that reference aspects of the tutorial process itself (Assertion:Process); domain concepts (Assertion:Concept), specific approaches to the solution of a problem, such as the application of specific mathematical/quantitative-reasoning operations (Assertion:Approach); and the use of lower-level mathematical/quantitative calculations (Assertion:Calculation). The most recent version of the taxonomy identifies 140 distinct dialogue acts and subact combinations. Of the 125 dialogue acts proposed previously by Morrison and colleagues, 8 were discarded, 8 were renamed, and 25 added. Tags were discarded for lack of use (e.g., Expressive:InstructionalContext), or because they were found to be redundant to other tags, e.g., Answer:PriorKnowledge:Negative turned out to be unnecessary given the availability of Confirmation:Negative as a response to a Request:Confirmation:PriorKnowledge. The twenty-five additional tags resulted from the addition of a new top-level category (Offer), some new subtypes (e.g., :Clarification, :Illustration, :ConfusionID, :Assistance), and a small set of previously unspecified Expressives (e.g., Expressive:Commiseration, Expressive:Reassurance).

4 Experiments and Results

We have used in our experiments a number of 222 tutorial sessions (containing about 11,393 utterances) in the area of Algebra between professional human tutors and students. The sessions were obtained from an organization that offers online human tutoring services for a fee. The sessions were manually annotated by a team of 6 subject matter experts (SMEs), e.g. teachers that teach the target topics, who were trained on the taxonomy of dialogue acts and subacts. The sessions were manually tagged by the SMEs independently and then a verifier, the designer of the taxonomy, ultimately verified and resolved any discrepancies. The verifier had full access to the tags assigned by the independent SMEs. The inter-annotator agreement for the two independent SMEs was kappa=0.79.

After deriving the features to be used in our machine learning models, we experimented with a number of machine learning algorithms including Naïve Bayes, Decision Trees, and Bayes Nets. The best results were obtained with Bayes Nets: accuracy for the top level dialogue acts was 65.73% and kappa was 0.56. For the 140 act-subact combinations the results obtained were: accuracy of 51.39 and kappa of 0.46. It should be noted that our results were obtained using a 10-fold cross-validation mechanism.

Our plans is to annotate more sessions up to 500 and retrain our models on more data. Once the accuracy is at acceptable level, we will use the trained dialogue-act classifiers to automatically tag with dialogue acts and subacts tens of thousands of sessions from which to infer relevant sequential patterns of tutor and student actions that could then be used in the development of automated intelligent tutoring systems or in a hybrid system where both human and intelligent tutors co-exist.

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Towards Applying Keller's ARCS Model and Learning by doing strategy in Classroom Courses

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Abstract. Recently, educational games are gaining increased interest from researchers since they are very motivating and interactive, and combine fun and learning strategies together. Therefore, teaching students how to develop their own educational games in universities is needed but challenging. Most courses available online simply use Portable Document Files (pdf) or Power Point (ppt), which can give students some information about educational games but not literally help them through the development process. This paper presents a pilot educational games development course evaluated with one hundred and thirty four undergraduate computer science students. In this course, learning by doing strategy and Keller's ARCS motivational model are applied. The results showed that learning by doing strategy and the ARCS model help in improving student motivation, keeps them active, and helps them gain the needed technical skills to develop their own educational games. Researchers and practitioners can therefore benefit by applying learning by doing strategy and the ARCS model during the development of their classroom courses. Furthermore, this research has resulted in a set of recommendations which can help teachers during the preparation of their educational games development classroom courses.

Keywords: Computer science education; educational games development; ARCS model; learning by doing strategy; Construct 2 game engine.

1 Introduction

With the rapid growth of technology in recent years, different mediums are being adopted for learning. One of these mediums is educational games. According to different studies, such as in [1, 2, 3, 4], these games: (a) are fun and keep students motivated during learning; (b) use various learning strategies; (c) offer a virtual

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environment for interactive, collaborative and decision making learning; and (d) model students and collect information about them.

To allow students to make use of games in general and educational ones in particular, various universities have started including game development courses in computer science programs [5]. This may prepare students to an industry which can get larger than Hollywood [6]. However, teaching educational games development in classrooms has many challenges. For example, resources about educational games development are limited. Many game development courses are available online but most of them focus on introducing students to the game industry and giving general information to students about game development process. In particular, only few courses focus specifically on educational games. There is also a general lack of skills to teach educational game development in universities. For instance, and from a practical experience, an educational games development course, which mainly focused on theoretical approaches and algorithms, was served to third-year undergraduate computer science students at University of Tunis. Consequently, the students found the course difficult and did not gain the required skills to develop their own educational games. Therefore, to allow students to gain the needed technical educational games development skills at universities, the main research question that this paper aims to answer is *How to serve a motivating and effective educational games development classroom course?*

In this context, this paper presents a pilot educational games development course presented at a public university in Tunisia. During the course development, "learning by doing" teaching strategy was used with the students rather than teacher directed lectures. In this strategy, the teacher and the students develop together an educational game from scratch. Furthermore, during this course, Keller's ARCS motivational model was applied to enhance the students' motivation.

The rest of the paper explores the proposed research question as follows: Section 2 first describes related works regarding the different game development tools which can be used during the learning by doing strategy and. the applied ARCS motivational model. Section 3 describes the goal, approaches and organization of the proposed course. Section 4 presents the obtained results from this pilot educational games development course. Section 5 lists further recommendations obtained from this practical experience which can help all researchers and practitioners in their context. Section 6 discusses and concludes the paper. Besides, it gives an overview about future directions based on this research.

2 Related Work

This section lists examples of game engines which can be used during the learning by doing strategy. Besides, it defines the ARCS motivational model and explains each of the four phases presented in it.

2.1 Game Engines

Different programming languages can be used to develop games in general and educational ones in particular, such as C# or Java. However, developing games with native languages can be difficult and complicated. Therefore, during the educational games development course, game engines were used instead for many reasons; these engines made the game development process easier by reducing the effort needed to create a game [7, 8]. In particular, ready-made functionalities defined within game engines [9] helped all interested in this field including students and teachers to create their own games without having programming skills. Various game engines for creating games in general and educational ones in particular are reported in the literature. For example, *E-adventure* [10] is a game engine for creating educational games in the first place developed by the e-UCM e-learning research group. It focuses on the "point-and-click" adventure games. *Construct 2* [11] is a game engine for creating 2-D games only developed by Scirra Ltd. It allows the creation of games in a simple way without any programming skills. This is done by using a graphical visual editor and event sheets which contain the code to be executed. *Unity* [12] is a game engine for creating both 2-D and 3-D games developed by Unity Technologies.

2.2 Keller Motivation Model

To deliver a motivating learning experience, Keller recommended taking into consideration four phases mentioned in his motivational ARCS model which are as follows [13, 14]: (1) Attention which refers to the interest shown by students to take and learn the information given to them. Keller suggested three strategies to grab the student's attention which are: perceptual arousal, inquiry Arousal and variability. (2) Relevance which highlights the utility of information given to students in their real life to make them more interested in the learning content. To achieve this phase, Keller suggested as well three strategies which are: goal orientation, motive matching and familiarity. (3) Confidence which focuses on establishing positive feelings within students that they can be successful. Keller suggested three confidence strategies which are: performance requirements, success opportunities and personal control. (4) Satisfaction which focuses on making students satisfied with this new experience and its outcome to remain motivated. Keller suggested three main strategies to promote satisfaction which are: intrinsic reinforcement, extrinsic rewards and equity.

After identifying the game development tools, which can be used during the learning by doing strategy, and the different ARCS motivational model phases that should be applied during the course development to motivate learners, the next section presents the way the educational games development course is designed and how the learning by doing strategy and ARCS motivational model are applied.

3 Course Design

This section presents the goal, organization and classroom design of the presented course. This gives an overview regarding the covered materials. Besides, it presents how the learning by doing strategy and ARCS motivational model are applied during this educational games development course.

3.1 Course Goal and Organization

The goal of the course is to teach students, by the end of the second semester, how to develop their own educational game. During this course development, all students reported they never developed a game before. Therefore, this course is presented in an easy and simple way. It is focused only on developing 2-D web (HTML) educational games. Mobile educational games were excluded from the course objective to avoid development complexity and technical constraints within mobile devices. Table 1 presents the different phases proposed in this course and the covered materials within each phase.

Table 1. Course phases and the covered materials.

Course phases	Covered materials
Educational games	**1.** Definition of games in general and educational ones in particular. **2.** 2-D vs. 3-D games **3.** Introduction to the different available game genres. **4.** Initiation to designing an educational game.
Game Engines	**1.** Definition of game engines. **2.** Comparison of various game engines. **3.** Introduction to *Construct 2* game engine.
Basics of *Construct 2* game engine	**1.** Graphical visual editor and event sheets. **2.** Layers and engine properties. **3.** Importing sprites and audio. **4.** Camera and effects.
Development of educational games	**1.** Implementation of educational game scenarios. **2.** Use of Artificial intelligence. **3.** Exportation of the developed game.
Home project	**1.** The use of the learned skills to develop an educational game.

As shown in table 1, the proposed course covers all the steps and needs to develop an educational game. The first phase introduces to students the context of the new course. This is done by presenting the definition, genres and methods to develop educational games. The second phase moves to present for students the different tools to develop an educational game. This makes students as developers aware of the available tools and have a solid and good background about each game engine in case they need to choose one among others in the future for a particular need (e.g. if the student wants to design a 3-D educational game, he/she will know that Construct 2 will not be any good for them). The third phase focuses specifically on the game engine Construct 2 which will be used during the educational game development course. Phase 4 implements an educational game with students using different scenarios and artificial intelligence. Finally, phase 5 offers students a chance to practice their learned skills through a home project where they have to choose a game genre and develop their own educational games. The next subsection describes how the course is presented to students within the classroom.

3.2 Course Classroom Design

The presented educational games development course lasted for four months during second semester. One hundred thirty four students took this course for one and half hours per week. They were divided into two classes. Each class (67 students) occurred in a big amphitheater at two different times (this allowed the same teacher to teach both classes). In addition, the amphitheater was equipped with a video projector. Students were asked to bring their laptops with them, if possible, to instantly apply what they learnt in classrooms using the game engine Construct 2 (presented in 2.1). This helped in creating some sort of computer lab sessions. The reason of choosing this game engine in particular was because it is easy to use and has a simple and friendly user interface. Thus, students would not need extra effort to learn how to use it.

3.3 Course Teaching Method and Strategy

Different teaching methods have been used in the literature to present game development courses, such as the use of lectures and presentations (classic teaching) or the use of a code of an already designed game to teach and explain the game development process (like the case of online courses or forums). However, these methods are not efficient enough to achieve the goal of the course which is to help students gain the needed technical skills to develop their own educational games in classrooms.

Therefore, the teaching strategy used in the course was "learning by doing" rather than teacher directed lectures. In this strategy, the role of the teacher during the course is a lecturer, a developer and a guide as well. He/she has to go through the development of an educational game from scratch while the students are applying what they are learning at the same time on their laptops. Also, when they face any difficulties or bugs, the teacher offers instant guidance to overcome them. This strategy allows students to be more engaging and active. Besides, it allows them to be a part of the developing process, thus, learning by doing and from their mistakes. Furthermore, to overcome the students' boredom in classrooms that teachers have been struggling with for years [15], Keller's ARCS motivational model was applied. The 4 phases of this model are applied during the presented course as follows:

Attention. To make students motivated and interested in learning educational games development course, members of an educational games research team were invited to the classroom. They introduced the term "educational games" to students and the different game genres. Besides, they explained to them how to design an educational game. Furthermore, they shared with them their real life experiences. In particular, these members presented examples of their, developed and published, educational games in international conferences and journals. These real life examples grabbed the students' attention and made them curious to know more about educational games. This has led to a constructive discussion where all the students' questions and previous believes about educational games are discussed.

Relevance. To further increase the level of motivation within students, relevance of the course with real life objectives are established [16]. For example, the new skills learned in this course can: (1) help students with their current issue which is the design of an original idea as their final graduation project and, (2) be a source of income in the future by selling their educational games. In this context, the new annual *Arab League Educational Cultural and Scientific Organization (ALECSO)*[1] Award for the best completed Arab applications in the fields of education, culture, science, and educational games where a 10-thousand-dollar prize will be allocated for each one of the four winning applications in the Arab world is presented.

Confidence. To maintain the motivation of students high, giving some encouragement feedback to make them gain more self-confidence is followed. Besides, the self-growth method where the development process was in small steps is applied (For example, the course focuses first on how to make the game character walk or run in the four direction). Every time a step is done, it is executed immediately to see how it works (the students can finally see the fruit of their work which is controlling their game character and make it walk). As a result, the students became more self-confident and more motivated to move to the next step of the course. Furthermore, students are given some freedom to control the learning sometimes by trying their new ideas (for example changing the attribute of their

[1] It is an organization that consists of twenty two independent Arab States. It works to coordinate cultural and educational activities in the Arab world.

game character so it can jump higher). This helped them to witness the success of their own ideas, hence take off elements of low-esteem and fear.

Satisfaction. To make students fully motivated and satisfied with the learning process, an award is offered (bonus points in the student's grades) for each student who will be able by the end of the course (at the end of the second semester) to return his/her own developed educational game. Besides, students are given a continuous sense of worth by reminding them about all their accomplishments and efforts. The main objective of this approach is to give students a small appreciation about their efforts during the learning process.

To validate the effectiveness of the application of learning by doing strategy and ARCS motivational model in the course, an evaluation was conducted, as presented in the next section.

4 Evaluation and Results

To evaluate the effectiveness of the proposed course, the number of students who succeeded to develop their own educational games during the home project was compared in both the proposed course and the traditional course (teacher directed lectures) which was served last year. Both students of the two courses are third year under-graduate students. Besides, they have both reported that they have never developed a game before. The results of this comparison are presented in table 1.

Table 2. Results of the home project evaluation.

Course	Total students	Students who succeeded in creating their educational games	Successful Rate
The proposed course	134	112	83.58%
Traditional course	121	76	62.80%

As shown in table 2, 112 students (out of 134) succeeded in creating their own educational games in the proposed course, while only 76 students (out of 121) succeeded in doing that during the traditional course. In particular, the successful rate in the proposed course (83.58%) is higher than the traditional course (62.80%). As a conclusion the provided course was more effective in helping students to develop their educational games by the end of the second semester.

As a second method to evaluate the proposed course, two types of observations were taken which are as follows:

Observations within the class: Many observations within the class were taken during teaching the educational games development course such as:

- *Observation 1:* Applying ARCS model made students very motivated. Consequently, their attendance of both educational games development classes was very high during all the semester compared to other classes. This shows that students were very interested to attend this particular course.
- *Observation 2:* Learning by doing strategy made students very interactive and curious. It is observed that most of them participated within the class to ask for some answers regarding different coding difficulties they encountered or even to think and propose other solutions during the development of the educational game together. This shows that students were active thinkers during the course and they were not attending the class just because they have to.
- *Observation 3:* Students were highly interested and immersed during the learning process. This is seen when they did not notice that they are sometimes over the course time (one and half hours).

Observations after the class: Various observations are taken after the class as well such as:

- *Observation 1:* Applying ARCS model within the course made students motivated enough to work by themselves on what they learned in class and even try new things. This is seen when students kept coming after the class to ask for help about some problems they faced when they are trying to implement some new scenarios or ideas.
- *Observation 2:* Some students decided to develop an educational game as their final graduation project. Besides, others decided to participate in the ALECSO award by creating a mobile version from their educational games (while the proposed course focused only on creating web versions of the educational game). Thus, the provided course, by applying ARCS model, did not make students only motivated but also self-confident about developing their own educational games.
- *Observation 3:* Many positive comments and feedback were given to students, who participated in the ALECSO award from other developers on the *AlecsoApps Store*[2], regarding their educational games. Also, many positive and encouraging feedback were giving to students who took educational games as their final graduation project from their examiners. Thus learning by doing strategy helped students gain technical skills to develop their own educational games. However, both comments from developers within the *AlecsoApps Store* and examiners agreed that further design enhancement are needed in the game interfaces.

[2] It is a Web-based application intended for hosting and gathering Arab mobile applications.

5 Recommendations

Despite the very motivating results obtained with the new designed and taught educational games development course, various recommendations based on this practical experience are found, which can help all interested researchers and practitioners in their context. These recommendations are as follows:

- A new course which mainly focuses on game art is highly needed. In this course, teachers should focus on enhancing the skills of students in creating game assets, animations and scenes. This can support developing educational games with good design game interfaces.
- An online platform where students can discuss what they have learned during the course or ask each other for a particular solution or help is needed. This is seen when the proposed course did not support students learning from each other's mistakes, solutions or ideas since everyone does not see or listen to what his/her friend did or said especially if the discussion occurs outside of the classroom.
- Learning by doing teaching strategy makes the classroom very interactive which leads sometimes to communication problems (between students/students or students/teacher). This is seen when students were too active and it happens sometimes that they all ask at the same time for some guidance or further explanation about a particular problem. Therefore, number of enrolled students in each class should not be large (max 25 student per class).

6 Discussion and Conclusions

This paper presented a pilot educational games development course conducted with one hundred and thirty four undergraduate computer science students in a public university in Tunisia. During this course, students were asked to bring their laptops with them to create some sort of computer lab session. Parberry et al. [17] highlighted that these sessions provide an effective learning environment when it comes to developing games. Besides, the Keller's ARCS motivational model is applied to keep students motivated while learning. Furthermore, the learning by doing strategy is followed where the students get to learn about educational games development by developing an educational game from scratch, with the help and guidance of the teacher, using the game engine Construct 2. Choosing a game engine for teaching educational games development instead of using native languages was supported by [18] where students found it hard to develop games using C/C++ for iPhone and needed a game engine to facilitate the process.

The obtained results showed that the proposed course helped students gain technical skills in developing educational games from scratch. Besides, it made them motivated and self-confident. However, some game art skills are still needed to enhance designing game interfaces. Educational games development requires various skills including game design and art [17].

Future work will focus on applying the recommendations presented in this paper to enhance teaching educational games development course. Besides, another game art course will be prepared by applying the same course design and teaching method followed in this paper. This will further support investigating the impact of using educational games development and game art courses on the skills of students when it comes to developing their own educational game.

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English Vocabulary Learning Performance and Brainwave Differences: The Comparison Between Gesture-Based and Conventional Word-card

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Abstract. Electroencephalogram (EEG) has utilized to measure individual physiological states since each individual's brain is the seat of cognitive activity, connecting body gesture to express ones' perceptual and mental imagery. This study explores the effects in preschoolers' brainwave pattern when learning English by comparing the two learning settings, gesture-based system, and conventional word-cards. The study found that: (1) student are not familiar with using gesture to operate the system, more sufficient learning time is required for children to learn new vocabulary in the gesture-based system; (2) the children aged 4-6 need straightforward pictures that are related to their learning content; and (3) the children have smaller head size, so the sizes of brainwave devices should be considered. That is suggested that more attention should be given on deciding the equipment used when collecting and monitoring children's brainwave. The limitations and future study of this study are also discussed.

Keywords: English as a second language, Gesture-based system, Embodied cognition, Electroencephalograph (EEG)

1 Introduction

Everyone's brainwave pattern differ from one another. It changes rapidly in accordance to individual actions, emotion, and cognitive load. Recently, many researches are conducted by monitoring individuals' brainwaves along with the increasing popularity of biometric devices such as EEG. On a global scale, English is the main language of communication. In Taiwan, the average starting age of learning English is gradually becoming younger as it is important for children to learn English. Additionally, there are extreme differences between Chinese and English in terms of character, method of writing, pronunciation, and grammar

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structure [1]. Hence, with English as a second language in Taiwan, different methods and approaches are discussed and applied to attract children's attention and to maintain their engagement in learning English.

Embodied cognition is one way applied into learning English nowadays [2], [3] which is a cognitive process that interacts with the learners' body [4]. As Gibbs and Feldman mentioned, from the perspective of embodied language, individuals' embodied activity can assist them to learn a language [2], [3]. This study explores the effects and changes in preschoolers' brainwave pattern when learning English by comparing two learning settings, gesture-based system and conventional word cards. The purpose of this study is to understand whether younger children's knowledge of the English alphabets and vocabulary by using gestures are different between the gesture-based and conventional word-card learning as well as their physiological message (i.e., engagement and cognitive load). The following are the main research questions (RQs):
RQ1：Are there any significant difference in the learning performance of the two learning activities between gesture-based and word-card learning?
RQ2：Are there any significant difference in the engagement of the two learning activities between gesture-based learning and word-card learning?
RQ3：Are there significant difference in the cognitive load of the two learning activities between gesture-based learning and word-card learning?

2 Literature Review

In the human's brain, there are more than 1 trillion neurons that communicate with each other by transmitting electrical signals, called electrical signals from neurons brainwaves. Kellaway indicated that EEG is classified into five type's brainwave signals: Delta (δ), Theta (θ), Alpha (α), Beta (β) and Gamma (γ). Each of them has the different frequency band, indicating different mental states and conditions. The frequency range of Delta is less than 4 Hz, Theta is 4 Hz to 8 Hz, Alpha is 8 Hz to12 Hz, Beta is 13 Hz to 30 Hz, and Gamma is more than 30 Hz. The mental states/conditions of each signals are: Delta (δ) wave is present in the state of deep sleep and unconscious; Theta (θ) wave is associated with intuitive, creative, recall, fantasy, imaginary; Alpha (α) wave is related to relaxation, peaceful; Beta (β) wave reflects alertness and agitation; and Gamma (γ) wave is about motor functions and higher mental activity [5], [6].

Many studies indicated that gesture (e.g., hand and body movements) can represent each individual's perception and their reactions towards specific actions [7]–[9]. Individual cognition can be built through the gestures made that emerge as a perceptual and mental imagery. Mental imagery is related to embodied cognition

[10]. Embodied cognition holds individual cognitive process, connecting body's interaction with the environment [4]. As Hung et al. mentioned, "theories of embodied cognition argue that mental model simulations in the brain, body, environment and situated actions are composed of central representations in cognition" [11]–[13]. Hostetter and Alibali also mentioned that "gestures are often considered to be valid evidence of the embodiment of language and cognition" [7], [12]. In other words, people use their bodies (i.e., gestures) to express knowledge, thus, their knowledge itself is deeply tied to the body.

"Since human brain is the seat of cognitive activity, the study of the brain should yield insights into the processes underlying human cognition" [14]. Engagement reflects mental engagement when an individual operate a task. Pop et al. and Freeman et al. indicated that individual engagement can be calculated based on the beta, alpha, and theta bandwidths [15], [16]. Cognitive load "refers to the amount of mental demand imposed by a task on a person, and has been associated with the limited capacity of working memory" [17]. Shriram et al. indicated that physiological measure (e.g., brain activity) is a proper way for monitoring cognitive load and it could reflect mental demands from body actions. Thus, it is useful to understand individual engagement and cognitive load when providing a new learning environment to children. The formula of engagement is [beta power / (alpha power + theta power)] [16]. This means that as beta activity increase, engagement would increase. The formula of cognitive load is [theta power /alpha power] [18]. The wave of Theta (θ), Alpha (α) and Beta (β) are considered to measure individual engagement and cognitive load.

3 Research Design

This study designed a gestured-based learning system for preschoolers to learn English that required all participants to not have the basic knowledge of English and are not familiar with English alphabets. By using the system, the children would learn the letters of English alphabet and the vocabulary of different body parts through gestures and movements.

As mentioned by Sühendan Er, children tend to have short attention spans [9]. This research designed a gesture-based system compacted with the learning contents of English alphabets and body parts vocabulary in 8 minutes. The learning content of the system consisted of 10 words related to limbs. The system utilized Microsoft Kinect to capture participants' gesture and used NeuroSky brainwave headset to collect the participants' brainwave data in order to directly monitor the participants' physiological message (i.e., engagement and cognitive load).

3.1 Participant

There were 20 subjects in this study whereby all are from a kindergarten in Kaohsiung. They are aged between 4 to 6 years old, and they just began to learn English in the school (not much prior experience on learning English). For the data analysis, only 17 participant's brainwave data were used because 3 participants' brainwave data were incomplete.

3.2 System Description

In this study, the participants were assigned into two groups randomly, gesture-based group and conventional word-cards group. The participants in the gesture-based group would learn both learning activities (i.e., English alphabet and English body parts vocabulary) through the gesture-based system by using their body gestures. On the other hand, the conventional group would use word-cards to learn the same learning content with an English teacher. The participants of both groups are required to wear the NeuroSky headset for their brainwave data collection. About learning content, the first learning activity consists of 18 English alphabets that made up of the alphabets used in the second learning activities – 10 vocabulary of body parts. The equipment used in this study included NeuroSky, Word cards, Microsoft Kinect and laptop. The study flow is described in Fig. 1

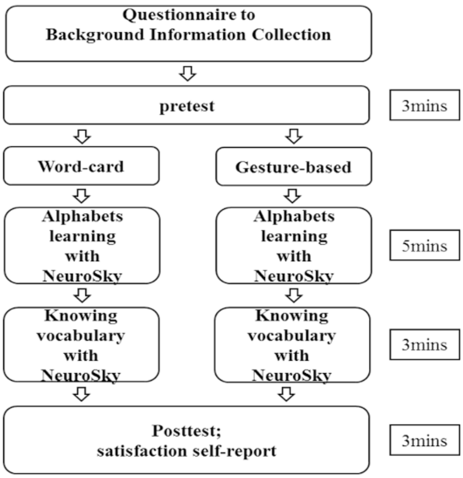

Fig. 1. The design process of the study

3.3 Procedures

Step1: Background Information Collection

A questionnaire on the background (e.g., gender, age), English level of the participants, and the experience of using gesture devices was given to the participants one week before we conducted the experiment. The parents of the participants would assist them in filling the questionnaire.

Step2: Pretest

On the day of the experiment, all participants would do the pretest together which was divided into two parts: Identifying the letters of English alphabet and connecting the English body parts vocabulary with the relevant figures.

A. Letters of English alphabet

We prepared 6 questions on identifying English alphabets. The recordings on the alphabets were played and the participants were requested to circle the alphabet they heard from the recording on their own test paper.

B. English body parts vocabulary

We prepared 6 questions on connecting the English body parts vocabulary with the corresponding figure. The participants would listen to the recording of the body parts vocabulary and match the vocabulary to the correct pictures.

Step 3: Randomly divided the participants into two groups

After the pretest, all the children were divided into two groups randomly, word-card learning group (control group) and gesture-based learning group (experimental group).

Step4: Learning activities

All participants were required to wear a NeuroSky brainwave headset during both learning activities in the experiment. The learning content of the two activities in the gesture-based group and word-card group were as follows:

A. Gesture-Based Group

(1) Activity 1 – Letters of English alphabet: The participants used the gestured-based learning system via Microsoft Kinect to learn the 18 alphabet letters while wearing the NeuroSky headset to collect their brainwave signals during the learning process. The system would display each alphabet for 5 seconds. The participants must use their body to pose/gesture like the alphabets. After the participant had made the correct pose/gesture, the system would read out the alphabets twice. The learning content were the 18 alphabets that are used in the learning content's body parts vocabulary consist of: A, B, C, D, E, F, G, H, K, L, M, N, O, R, S, T, U, W. This session would last for five minutes.

(2) Activity 2 – English body parts vocabulary: The participants wore the NeuroSky headset during this learning activity as well. The system would display a diagram of the complete body part vocabulary listing along with

pictures. Next, the system would display each body part vocabulary and the picture of the body part. The participants were required to point out the right spot on their own body. Once the participant had pointed the correct part of their body, the system would read out the vocabulary and move on to the next vocabulary. Each vocabulary would be repeated twice. This session would last for three minutes. The learning content includes 10 English body parts vocabulary (HEAD, NECK, SHOULDER, CHEST, ARM, ELBOW, KNEE, BOTTOM, LEG, and FOOT).

B. Word-card group

(1) Activity 1 – Letters of English alphabets: a set of word cards were prepared. We invited an English teacher to teach the participants the 18 alphabets by using flash word cards while wearing the NeuroSky headset. The teacher would lead the participants to learn these alphabet letters until the time was up (five minutes).

(2) Activity 2 – English body parts vocabulary: The participants wore the NeuroSky headset during this learning activity as well. The same teacher would teach the participants to learn the body parts vocabulary by using word cards. This learning session lasted for three minutes. The learning content was same as the gesture-based group. The teacher would lead the participants to learn these body parts English vocabulary until the time was up.

Step 5: Post-test and Satisfaction self-report

After completing the two learning activities, the participants were required to complete the posttest. The test's methods were the same as the pretest consisting two parts – letters of English alphabet and English body parts vocabulary, but with different the questions. In the Satisfaction self-report, the participants were asked to share their satisfaction with two learning activities in this study after having posttest. This was to gain insight on the learners' learning experience.

4 Results and Discussion

The participants of this study were 67% female (n = 6) and 33% male (n = 3) in gesture-based group; 21% female (n = 3) and 79% male (n = 5) in the word-card group. Most of the participants didn't go to cram school (gesture-based learning group n = 9, 100%; word-card learning group n = 7, 88%) and didn't have past experience of using gesture-based systems (gesture-based learning group n = 7, 78%; word-card learning group n = 7, 88%). Half of the participants have not been exposed to English in their daily life including watching cartoons and discovery programs (gesture-based learning group = 44%; Word-card learning group = 50%).

To understand the participants' English prior knowledge levels, this study conducts an analysis of covariance (ANCOVA). Table 1 shows that there are no significant different in the pretest between gesture-based and the conventional word-cards groups (p > 0.05) in English alphabet and body parts vocabulary. This means that the participants' prior knowledge of English are the same for both groups, both in terms of the English alphabets and body parts vocabulary.

Table 1. Descriptive data and ANCOVA results of the pretest in the two learning activities

Groups / Pretest	Gesture-based Group			Word-card Group			*F* (2, 297)
	N	M	SD	*N*	M	SD	
Alphabet	9	4.444	1.0138	8	4.000	1.852	6.191
Body parts Vocabulary	9	1.889	1.054	8	0.500	0.535	1.047

To answer RQ1, we used ANCOVA to treat pretest score as a covariate and our variable of interest, the two learning groups (i.e., Gesture- based group and Word-card group) during the two learning activities respectively. Table 2 illustrates the results of the learning performance (posttest) in the two learning activities between gesture-based and word-card learning. It shows that there is no significant difference in the learning performance (posttest, p > 0.05) of the two learning activities between gesture-based learning and conventional word-cards learning.

Table 2. ANCOVA results of the posttest in the two learning activities

Posttest	Group	*N*	M	SD	*F* (2, 297)
Alphabet	Gesture-Based	9	4.00	1.871	0.001
	Word-card	8	4..333	1.852	
Body parts Vocabulary	Gesture-Based	9	1.222	1.093	1.250
	Word-card	8	1.625	1.685	

Comparing the mean scores of pretest in Table 1 with the mean scores of posttest in Table 2, using the word-card (ratio of pretest: posttest is 4:4:333) to learn the English Alphabets has slighter improvement than using the gesture based learning (ratio of pretest: posttest is 4.444:4). For the English Body parts vocabulary learning activity, Table 1 and Table 2 also shows the same results as the English Alphabets activity, with the ratio of the pretest: posttest for the word-card group of 0.5: 1.625; and the ratio of the pretest and posttest for the gesture based group of 1.889: 1.222. Additionally, according to above results mentioned, we found that the participants had better performance in the English Alphabets learning than English Body Parts Vocabulary learning.

The following are reasons in accordance to our observation and the feedback received from participants: (1) the duration of the second learning activities may be too short. The English alphabets learning time was 5 minutes, and the body parts English vocabulary learning time was only 3 minutes; (2) there is no practice section for the participants to familiarize with the gesture-based system; and (3) some images of the body parts vocabulary did not indicate directly to the exact body parts. The participants can't directly understand the meaning of some pictures on the body parts vocabulary. Thus, we argue that the learning duration should be lengthened especially during the body parts vocabulary session in the gesture-based system; and the pictures used for the children whose age are between 4 to 6 years old should indicate the learning content directly (i.e., the body parts vocabulary).

There are many methods to analyze the EEG brain signals [16], [19], [20]. The two main parts of EEG data process in this study were (1) to decompose these brain signals into simpler components by performing principal component analysis (PCA); and (2) to use panel regression models (PLM) to do statistical analysis. To explore the difference of the participants' engagement (RQ2) and cognitive load (RQ3) in the two learning activities between gesture-based learning and word-card learning, the principal component analysis (PCA) was conducted on the Theta (θ), Alpha (α) and Beta (β) brainwave data. These brain signals data were decomposed into simpler components, since over 300 seconds and 180 seconds of brainwave data were collected for 20 participants during both learning activities – English alphabet and its body parts vocabulary, respectively. Also, the first principal component scores were taken into account from the brainwaves for two learning activities, as theses scores account for most of the variability of the brainwave dynamics. EEG data (e.g., alpha and beta waves) are time series that vary from person to person. Thus, we considered panel regression models to analyze such multiple time series in order to elucidate the relationship between children brainwave signals and the two learning activities. The formula of engagement is [beta power / (alpha power + theta power)] [16] and The formula of cognitive load is [theta power /alpha power] [18].

In Table 3, it is shown that there is no significant difference in engagement and cognitive load between gesture-based learning and word-card learning ($p > 0.05$), either on the English alphabets or body parts vocabulary. The results indicated that the children who learned English through gesture-based learning do not have different engagement and cognitive load compare to the conventional word-cards learning in this study. There are some issues found during brainwave data collection that which may affect data accuracy. First, some participants' brainwave device kept falling off, resulting 17 out of 20 participant's brainwave data were used in this study. Although we had 17 participants' brainwave signals, we suspected some of these brainwave data may have also been affected. Second, the children at the age of 4 to 6 may not capable of wearing the NeuroSky headset due to the smaller size of their heads. Thus, to accurately collect children's brainwave signals, more attention should be made on the decision of the device used in accordance with the target participants.

Table3. The results of engagement and cognitive load for the two learning activities

	Variable	*N*	*t*-value	*p*-value
Engagement of English Alphabets	Gesture- based	9	0.147	0.883
	Word-card	8		
Engagement of Body parts vocabulary	Gesture- based	9	1.241	0.215
	Word-card	8		
Cognitive load of English Alphabets	Gesture- based	9	0.134	0.893
	Word-card	8		
Cognitive load of of Body parts vocabulary	Gesture- based	9	-0.995	0.320
	Word-card	8		

5 Conclusion

This study intends to investigate young children's learning performance in English under two learning settings, the gesture-based learning and conventional words-card learning. Although the findings showed that the children's learning performance of two learning activities in the conventional word-cards group has better than the gesture-based group, we found that that the presentation of the picture used and the time limitation of the second learning activity may affect the participants learning performance. Besides that, there is no significant difference in engagement and cognitive load between gesture-based learning and word-card learning. However, we found that when collecting and monitoring the brainwave signals of younger children, more attention should be given on deciding on the equipment used.

There were some limitations of this study. Firstly, all the participants came from Kaohsiung, Taiwan, so the result might not be suitable for other regions. Secondly, the total learning time of this research was 8 minutes, this might be too short for the children to learning English. Thirdly, adding practice section and providing a clearer image of the body parts should be considered. Lastly, the EEG headset is not suitable for 4-6 years old children, there may be better devices in the market to collect these data accurately.

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The Effect of Children Learning English Vocabulary through a Gesture-Based System

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Abstract. English as a second language is catching up in Taiwan as the government placed strong emphasis on its importance, resulting to have parents having their children to learn English at a younger age. This research used a gesture-based system for children to practice spelling of the body parts English vocabulary. The results found that the participants in the conventional group had better performance compared to the gesture-based for children of 10 to 11 years old. This findings emphasized on the importance of the system's design, such as: (1) practice session for participant to familiarize with the function of the system; (2) sufficient time to learn the learning content; (3) context-awareness design; (4) clear interface presentation; (5) an appropriate experimental environment. The limitation and future research directions are also discussed.

Keywords: English as a second language, Gesture-based learning system, Kinect, embodied cognition

I. Introduction

In Taiwan, learning English as a second language is important and the starting age of learning the language is progressively getting younger. Learning English is different from learning Chinese in terms of writing, pronunciation, and grammar structure[1] . In order to remember new vocabulary, children need to spell verbatim along with the vocabulary. Embodied cognition is a cognitive processes that interact with the body [2]. From the perspective of embodied language, it is a lexical task that refers to embodied perceptual and motor experiences in language understanding [3]. Although research on gesture-based learning systems are conducted [4]–[7], only few research has focused on children spelling English. We focused on enhancing the understanding of body parts English vocabulary and increasing their interests to learn English through gestures activities. The research question of this study is: Whether the gesture-based learning is more effective than the conventional way by using blackboard in learning English vocabularies for children of 10-11 years old?

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II. Literature Review

When our body is in touch with the physical world, these sensory impulses will be detected by our nerves and they are transferred to the brain, making cognition to occur for us to perceive what we encountered. Hence, having gestures can be valid evidence of the embodiment of language and cognition [8]. As Claxton mentioned, children physical experience should help children's mental activities [9]. Embodied cognition is a combination of natural user interface with user's cognition state that has been used into gaming, mobile device, and learning[4]. Gibbs mentioned that "Human language and thought emerge from recurring patterns of embodied activity that constrain ongoing intelligent behavior [10]." With the assistance of technology, the combination of body interactions and visual representations could enhance learner's experience in understanding and retrieving new knowledge[11]. Many studies indicated that gesture-based interface is a method that offers students more intuitive and interactive ways to learn a content in multimedia learning environment [12][13]. One of the most popular technology used in gesture-based learning system is Microsoft Kinect sensors. It has sensor to detect the speech context of users, detects users' gesture and movement, and interpret users' movements and translate these actions into a meaning [14].

III. Research Design

We designed a gestured-based English learning system that connected with Kinect motion detection, allowing children to learn and spell the body parts English vocabulary through gestures. The research design details of this study is as follow:

Participant

A total of 38 participants (25 males and 13 females), aged 10-11 years old were involved in this research with the cooperation with an Elementary School from Kaohsiung, Taiwan.

System description

We designed a set of gesture-based English learning content with 10 body parts English vocabulary which were large limbs as our learning content. There were two sections in the learning content, with a total of 8 minutes learning time. The 10 body parts English vocabulary were: HEAD, NECK, SHOULDER, CHEST, ARM, ELBOW, KNEE, BOTTOM, LEG, and FOOT. The total time of the experiment including the pretest and the posttest is about 14 minutes. The equipment used in this study included Blackboard, Kinect and computer.

Procedures

Background Information Collection

A questionnaire regarding the participants' background information was given to the participants one week before we conducted the experiment.

Pretest

Before the children were separated into two groups, they would take the pretest together. The pretest required children to fill in the missing alphabets of five body parts English vocabulary in around three minutes.

Learning Process Description

The participants were separated into two groups in a random manner. The two learning sections designed for the participants to learn these vocabulary in this study as follows.

A. The Conventional Group

The learning contents were divided into two parts:

(1) Section 1: Familiarize with Vocabulary

With the time constrain of five minutes, we invited an English teacher who used the blackboard to teach the children to acquaint with the vocabulary.

(2) Section 2: Spelling Vocabulary

The learning contents consisted of spelling body parts vocabulary that were related to 10 big limbs. The teacher wrote on blackboard, teaching children to spell out and combine letters into vocabularies with a time limit of three minutes.

B. The Gesture-Based Group

The learning content and time were the same as the conventional learning group. However, the learning method of this group was by using the gesture-based system with Kinect. The program included two parts:

(1) Section 1: Familiarize with Vocabulary

The children would learn and acquaint the body parts English vocabulary by making gestures similar to the system's prompted pictures. If the participant had made the correct gesture, the system would display and read out the vocabulary of the corresponding body part. Participants would have five minutes for this part.

(2) Section 2: Spelling vocabulary

During the learning process, the system would display the pictures of the body parts along with the English vocabulary one by one. The participants had 10 seconds to memorize each vocabulary and the vocabulary will be hidden. The system would also ask the participants to begin to grasp the alphabets on the screen in order to spell the vocabulary of the shown body part. If the participants had spelled correct, the system would read out that vocabulary and move on to the next vocabulary. Participants would have three minutes for this part.

Post-test and Satisfaction Questionnaire

After the participants of both groups had completed the two learning sessions, the participants were required to take a posttest by filling in the missing alphabets parts vocabulary and the pictures of these parts were prepared to assist children in filling the blanks. This was similar with the pretest but the content of the test was different. After completion, the children would then fill up the Satisfaction Questionnaire.

IV. Result

In order to conduct the analysis of the results of this study, an analysis of covariance (ANCOVA) is conducted with posttest score with the two covariates, pretest score and our variable of interest, the two learning groups. Table I shows that the pretest score has no significant effect on the posttest score, meaning the learners' performance in their pretest do not have significant effect on their posttest score. However, the learning group of this study has a significant effect on the posttest score. As shown in Table I, the gesture-based group's learning performance (mean = 2.316) significantly fall behind the conventional group (mean = 3.316). Hence, this shows that the conventional group actually had better learning performance compared to the gesture-base group.

TABLE I. RESULTS OF ANCOVA ON PRE AND POST TEST WITH LEARNING GROUP

	Variable	Mean	SD	t-value	p-value
Pre-test	Conventional group	1.842	1.167	1.413	1.413
	Gesture- based group	2.579	0.769		
Post-test	Conventional group	3.316	1.945	-2.064	0.0465*
	Gesture- based group	2.316	1.797		

Note. $^{*}p < 0.05$.

In Table II, a total of 38 satisfaction questionnaire were received. From the data, most of the participants know what they learned and enjoyed the lesson. However, some of the participants did not enjoy because the gesture-based learning was not easy to control.

TABLE II. RESULT OF THE SATISFACTION QUESTIONAIRE BY THE TWO LEARNING GROUPS

Variable		**Learning group**			
		Gesture-based		***Conventional***	
Know what they learn?	***Yes***	18	95%	15	79%
	No	1	5%	4	21%
Have fun?	***Yes***	16	84%	12	63%
	No	3	16%	7	37%
Want to learn by self or together?	***Self***	2	11%	5	26%
	Together	17	89%	14	74%

V. Discussion

This study aims to investigate the learning performance of young children in learning English vocabulary using two different learning environments. The result is different from previous studies that indicated "learning process with bodily action and environmental interventions may lead to a better learning performance”[1], [13], [15]. The gesture-based learning in this study did not improve the learning performance compared to the conventional learning. In contrast, our results shows that children who have been taught in the conventional way have better learning performance than gesture-based learning.

Based on the experimental observation, we found that these are some issue on the system design of gesture-based learning. First, Section 2 – “Spelling Vocabulary,” it lacked the element of connecting the learning content with body gesture. Instead, it only asked participants to grasp the alphabets on the screen. Thus, a context-awareness design is necessary in this study. Second, the participants’ faced difficulties in navigating the cursor resulting some participants to stop during the session or felt discouraged. Third, there might be too many alphabet shown in the interface for participants to choose from to spell a word. These issues might impede the children English spelling learning performance.

Moreover, the experimental environment issue may had affected the results of this research. A semi-open environment may disturb Kinect accuracy causing error in detection. Besides that, peers disturbance may had affected the research as well. Students in the school may walk around the hall causing a distracting to the participants and also to Kinect’s detection. These environment noise may cause be a disturbance to the participants learning performance.

According to these findings, we argue that the gesture-based learning system may need further improvements such as separating learning time and practice time, re-designing the presentation of the system’s interface and considering context-awareness and the experiment environment. For instance, the system should provide a practice session to assist the participants in familiarizing with the gesture-based system before starting the learning sessions. On the improvements on the presentation of the system’s interface, the cursor has to be bigger and clearer. For Section 2, the number of alphabet selections has to be reduced to shorten the participants’ time used in searching for the alphabets. Most importantly, in designing a gesture-based learning system, we should ensure that gestures are incorporated into the learning content.

VI. Conclusion

This study designed a gesture-based learning system to assist fifth grade students in learning English vocabulary. Although the results of this study indicates that the children with conventional learning had significant improvement and better learning performance compared to the gesture-based group, we found some issues with the gesture-based system during the research.

There were some limitations for this study. Firstly, the design of the system can be further improved as some children felt that it is difficult to grasp the alphabet during the spelling session. Secondly, the environment of the research has to be taken into consideration in order to optimize the results of the research. Lastly, the total learning time of this research was 8 minutes, this might be too short for the participants. In future, the study could learn from this experience and consider looking into a long term study whereby participants could access the system for a longer period of time.

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Online Test System to Reduce Teachers' Workload for Item and Test Preparation

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Abstract. An online test system has been designed and implemented to provide teachers with end-to-end solution to streamline student assessment process as well as saving them time and efforts of preparing test questions – the system can automatically generate items, based on the knowledge map teachers created, for teachers to pick-up and form their tests. Moreover, students can take advantage of the system to do self-assessment at anytime and anywhere. This paper focuses on providing insights on the features available for the uses of the system.

Keywords: Knowledge Map. Item Generation. Hierarchical Concept Map. Concept Schema. Online Assessment.

1 Introduction

Many researchers in the literature have used different techniques and architectures (e.g., Client/Server [1-3] [5] and Web Service [4]) to develop assessment generation systems. The intention has primarily been to reduce the time and efforts that teachers spend in preparing the tests, in particular, multiple choice questions, and to mark students' answers. Most of these systems, however, have been developed without considering modular design, which makes it difficult for various components of these systems to be further enhanced and tested. Furthermore, most of these systems provide features for users to only enter test questions to item banks instead of generating questions automatically to populate the item banks. The research solution proposed in this paper leverages HTML5 and JavaScript to design and implement an Online Test System that can automatically generate items according the knowledge maps created and associated to a course by teachers. Teachers can choose the generated items from the item bank and create their own favorable tests for students to do self-assessments and to undertake quick quizzes to analyze how much they have learnt from the classes.

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The rest of this paper is organized as follows. Section 2 details the features available to the teachers and explains how to use them. This is followed by Section 3, which discusses the benefits of the systems for teachers and possible future directions of the project.

2 System Features for Teachers

The Online Test System developed in this research has the following features available for teachers (as shown in the menu on Fig. 1): checking courses assigned to them, creating knowledge maps for their courses, importing knowledge maps created by themselves or others, creating accounts for students, creating tests for their courses, and reviewing students' answer sheets of the tests.

First of all, a teacher can see his or her courses by clicking the Assigned Courses link on the menu. For each of his or her courses, he or she can associate one or more knowledge maps to the course. Two ways a teacher can have a knowledge map for his or her courses are as follows: (1) creating by himself or herself; and, (2) importing existing ones created by other teachers.

The teacher can click "Knowledge Maps" option on the left side menu to display a list of knowledge maps he or she has created. A knowledge map is composed of a hierarchical concept map and concept schema [6]. He or she can manage the items on the hierarchical concept map on the left by clicking an item and using the Add, Update, and Delete functions. When the teacher clicks "Root" item on a knowledge map (Fig. 1), the corresponding concept schema is displayed for him or her to review and edit.

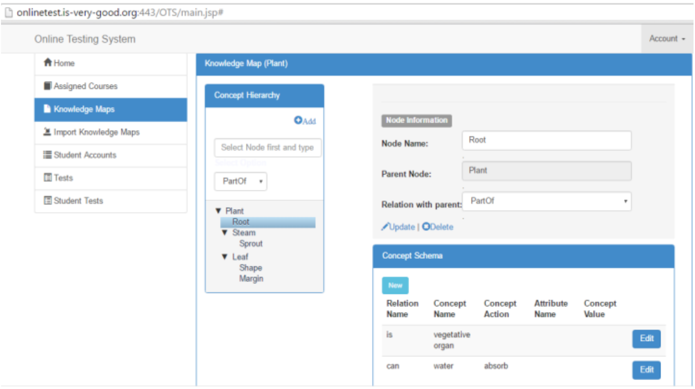

Fig. 1. Knowledge Map Editor

Alternatively, a teacher can click on "Import Knowledge Maps" from the left side menu to see a list of knowledge maps that have been created by others, as shown in Fig. 2. Then he or she can select one or more knowledge maps and click on "Import" button to have a copy. He or she can then modify the imported copies freely and associate them to his or her courses.

Fig. 2. Teacher Importing Knowledge Maps

Next, the teacher can manage tests for his or her course by clicking on "Tests" link on the left side menu. Fig. 3 shows that the teacher has selected the course "Introduction to Botany" from the drop down list and three existing tests associated to the course are listed. He or she can click the "New" button to create another test for the course. Once teacher has entered all necessary details, including test name, marks, start date and time, as well as end time, the new test will be shown on the list.

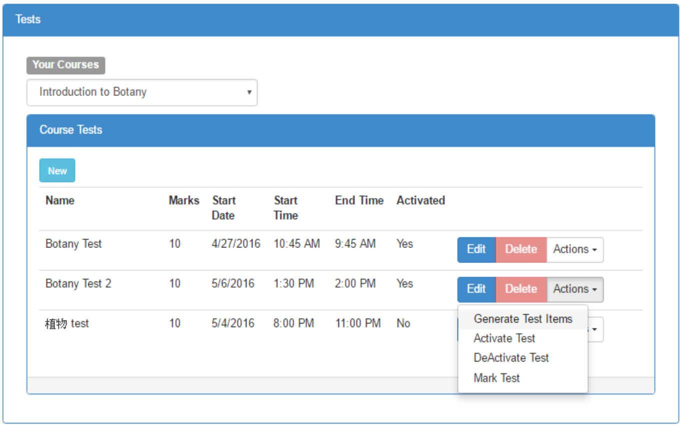

Fig. 3. Teacher created new test "Botany Test 2" for course

The teacher can then ask the system to generate items for him or her to include in the test by choosing "Generate Test Items" via clicking its "Action" button. Fig. 4 shows the Test Generation Editor where the teacher can select a particular concept from the knowledge map at left side and choose different cognitive levels (two levels have been implemented at the moment, namely Classify and List) and different item type (true/false and multiple choices have been implemented at the moment) as well as decide the item's nature (i.e., if he or she wants the item to ask students to identify correct or incorrect concepts) so that the system can generate possible relevant items for him or her to consider. The generated items are added to "Test Question Bank".

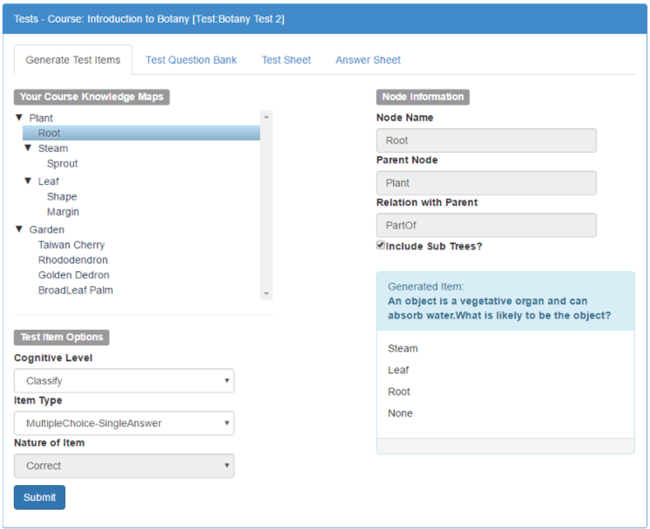

Fig. 4. Teachers ask the system to generate items for particular concept for them

Finally, the teacher can select generated items from the question bank, add them to the "Test Sheet", and set the mark and correct answer for each test item, as shown in Fig. 5. He or she can also select items and remove them from the test sheet at any time. After he or she presses "Submit" button, the system generates a benchmark "Answer Sheet" that will be used by the system to mark student answer sheets.

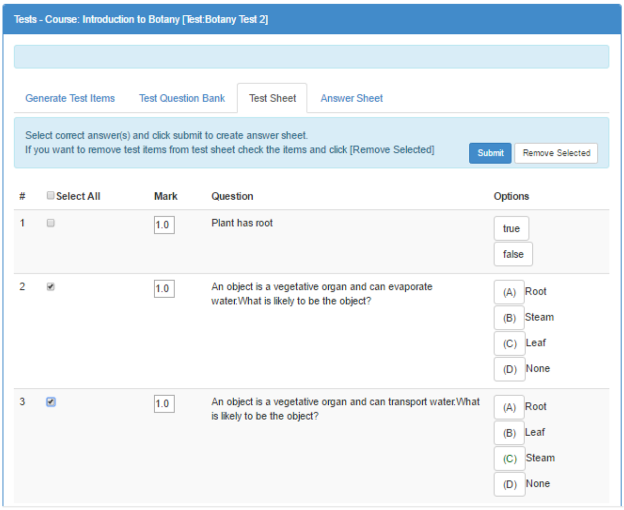

Fig. 5. Items selected by teacher will be added to the Test sheet when he or she clicks "Submit"

3 Conclusion

The Online Test System[1] is a responsive system implemented for teachers to automate the student assessment process. The research team would like to collaborate with teachers and schools to test the usability of the system as well as obtaining users perceptions and comments to help us enhance the system. The hope is to extend the system to generate higher order thinking question to help teachers assess students' critical thinking.

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Breadth and Depth of Learning Analytics

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Abstract. This paper presents a learning analytics system that has been extended to address multiple domains (writing and coding) for a breadthwise expansion. The system has also been infused with analytics solutions targeting competence, grade prediction and regulation traits, thus offering deeper insights. Our experiences in extending the breadth and depth of the analytics system have been discussed. The discussion includes elaboration on two types of sensors to track the writing and the coding experiences of students. The design of a dashboard for teachers to monitor the performance of their classrooms and advocate regulation activities is also included. The discussions lean more on the side of teachers, parents, and administrators, than on the side of students.

Keywords: learning analytics • coding • writing • sensors • dashboard • teacher • grade prediction • rubrics • competences • regulation

1 Introduction

This paper introduces new educational technologies that encourage and promote quality learning and greater accessibility toward education. The full range of benefits of emerging educational technologies can be felt when their impact on teachers, parents, and school administrators is readily seen, in addition to their impact on students. For this reason, the discussions tend to favour the viewpoints of teachers, parents, and administrators, rather than students.

Learning analytics traces study episodes of students and measures learning products and learning processes of students in a continual manner. These measurements allow one to infer learner capacities and traits, which are usually not directly observable. Further, these measurements also allow educators to personalize instruction to cater to individual students. In summary, learning analytics is a means to augment the teaching and learning experiences of teachers and students as well as to increase the awareness of all education stakeholders in the learning process. Typically, learning analytics solutions tend to focus on one specific aspect of the student's learning process rather than a combination of multiple aspects [1, 2, 3, 5, 6]. This paper presents a learning analytics system based on the concept of learning traces. Learning traces are instantiated network of

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computer models that lead to a measurement of learning. This new definition of learning traces is different from an earlier belief, where it considered each node to be a variable associated with a learning trait [4]. Learning traces are captured from study episodes of students and from analytics solutions. The expanded learning analytics system discussed in this paper analyzes the student's learning skills in various learning domains such as math, writing, science, music, coding as well as meta learning skills such as self-regulation, and use them as a whole to create a picture of the student in terms of his/her learning experiences.

This paper introduces the current version of a learning analytics system comprising of sensors and dashboards that allow teachers to track the writing and coding habits of students, assess their competences in English writing and coding of computer programs, provide students with a formative feedback in each learning activity, and more importantly, allow teachers to create and assign goals to motivate students to reach excellence. The system also assists teachers to identify students at risk and provide them with remedial interventions.

2 Sensors

Sensors are embedded in students' learning activities to observe their progress and send those observations to the teacher dashboard. Two domain-specific sensors have been independently developed that would send streams of observational data to the learning analytics system. One sensor tracks students' coding habits in the NetBeans environment while the other sensor tracks the writing habits of students in the Moodle environment. Although only two sensors have been developed and tested so far, the knowhow enables the development of a variety of sensors targeting a range of domains. These sensors sense data in the background thus allowing students to study naturally. That is, the sensors do not intervene in the study episodes nor disturb the study experiences of students.

Data observed by the sensors are transported to the learning analytics system over the Internet in a lossless manner. The sensors smartly detect the availability of Internet connectivity and store the data locally until the connection is available at a particular quality. Until the Internet connectivity is established, data will be stored in local machines using tamper-proof custom encryption. The confidentiality and privacy of those data will be maintained throughout the transmission until safe storage on server as per the modular solution presented in [7].

3 Teacher Dashboard & Use Cases

Once the data is safely stored on the learning analytics system's server and decrypted, students' work is analyzed through a set of analytics solutions that offer a number of insights about students' study habits and competences to the teacher. This includes interactive visualizations such as a competence portfolio, an automatic grader that provides feedback to students over every learning activity, a tool where the teacher can assign goals to students to help them learn manage their learning and ensure constant progress, and visualizations showing the overall progress of the classroom with the possibility to identify at-risk students and offer remedial interventions. For the first time, the concept of a student-adapted and competence-based self-regulated learning tool has been implemented in a learning analytics platform as suggested in [4]. Fig. 1 shows the various components in the teacher dashboard. When a student performs a learning activity, observations from the student's work is recorded at regular time intervals and sent to the learning analytics system's server. Harvesting of such student traces leads to new evidences directly observed from the student's work. These traces enable the learning analytics system to estimate proficiencies of the student.

For example, a teacher observes how a student struggles to develop the topic flow in his essays. By visualizing the competence portfolio of that particular student within the teacher dashboard, the teacher noticed that the topic flow competence is critically low. To remediate that deficiency, the teacher decides to set a goal for the student. The teacher wants to incite the lagging student to catch up with the classroom within a four-week period. The teacher therefore expects that the student will have reached a competence of 50% by that time. In addition, the teacher also assigns the student a strategy to put into action the remedial plan that is revising thoroughly his previous essays. When the student will log in his dashboard, a green-bar will appear on top of his at-risk competence to indicate that a goal has been set by his teacher. Once the goal will be completed, the goal will be saved in the student's record and will be consulted subsequently by his teacher. The student will gain a badge for each achieved goal. Goals achieved on time will be awarded a more prestigious badge.

As part of the strategy to improve the student's competence, the teacher recommends the student to submit regularly his essays to the automatic essay grading system. The student will not only receive predicted grades for an assignment, but also feedback on his performance in relation to scoring rubrics that underlie the teacher's grading process. The student will therefore be able to watch more closely the rubric that assesses the topic flow of his essay. Feedback will also be provided not only based on the auto-marking of the current version of the draft but also as a function of comparison of the current draft against previous drafts. Simultaneously, the dashboard will allow the teacher to view the number of times the student received feedback on an assignment, and how well that student improved his competence over time, that is how engaged the student was to reach his goal.

As the teacher provides personalized tutoring to this particular student, the teacher will continue to monitor his classroom for any other student in difficulty. At a glimpse, the teacher will be able to perceive in the teacher dashboard the proportions of top students, average students, and at-risk students and this, for each

Fig. 1. Teacher dashboard. It shows the process (cycle) by which a teacher monitors his/her classroom and provides remedies to at-risk students.

competence in particular. The teacher can therefore visualize clusters of students based on levels
of performance. Individual students can then be spotted within these groups so that the teacher can analyze more deeply the performance and competences for each of them. Then the learning analytics cycle as just explained will start again with the creation and assignment of new goals to students as depicted in Fig. 1.

As for parents, parts or totality of these insights can be shared with them to promote better synchronization of the teachers' and parents' efforts in scaffolding a child's learning process. For example, parents may tutor their children aligned with the teacher's strategy to ensure that they meet all their goals.

4 Future Work and Conclusion

As part of the improvements on the current system, the breadth and depth of the learning analytics system have been extended to allow teachers to find ways to optimize student learning since they have a reasonable handle on the study patterns and capabilities of students. This extension continues with new analytics solutions being added to the system such as the granularity and variety of goals giving teachers, parents, and students greater control over the learning process, as well as a personalization and adaptivity module recommending learning and remedial activities to teachers, parents, and administrators. The current system will be demonstrated at the workshop along with hands-on writing and coding activities for the participants, joined to various interactions with the teacher dashboard.

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Educational Resource Information Communication API (ERIC API): The Case of Moodle and Online Tests System Integration

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Abstract. Educational Resource Information Communication (ERIC) API has been developed which enables the integration of two separate system and enhance their interoperability while keeping both systems working independently like they were. The proposed API can be easily inserted or attached to any system through making no or very little modifications to the system. With ERIC API's help, educational technology researchers can make their research (i.e., educational games) available and accessible for the potential users as the stakeholders don't need to put many efforts in terms of integrating their systems into the platform the stakeholders like schools are currently using. This paper mainly focuses on the workflow of the developed ERIC API and talks the case of integrating Moodle and Online Tests System (OTS) so students can grant Moodle permission to access the information of the tests they are supposed to take, whether or not they have completed particular tests, and how they performed in the tests.

Keywords: Privacy. Learning Management System. Machine to Machine. Secure Communication. Authorization. Anonymity.

1 Introduction

Werkle et al. [5] proposed a Personal Learning Management System which uses OpenSocial API to combine the functions of a learning management system (CLIX Learning Suite) and a personal learning environment (LearningTube) to give students a better learning environment according to their learning history, goals and preferences. Vozniuk et al. [4] also designed three learning analytics apps with OpenSocial API for a social media platform for collaboration and learning, Graasp, based on the results of requirement analysis from 32 teachers' opinions. Kardara et al. [3] designed SocIoS API and framework on the top of seven popular social

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nwtworks (i.e., Dailymotion, Facebook, FlickR, Google+, Instagram, Twitter, and YouTube) so components can access social networks' data via a uniform access mechanism.

Although OpenSocial API and its derived specification and frameworks can help to integrate functions that other applications and social media sites provide, the integration requires users' credentials of the system which provides the features or data that they want to use or access. OAuth is an authorization standard that allows an OAuth client application to access the resources stored in the OAuth server on behalf of the resource owner and not requires the owner to share his or her credential [2]. It may be a good solution for integrating lightweight applications and widgets into a learning management system. However, OAuth solution may not perfectly work to solve the need when we want to integrate two applications (or more) and each of them has its own authorization process for users.

This research aims to develop an Educational Resource Information Communication Application Program Interface (ERIC API) which can be plugged into internet-based systems so users of one system will not need to provide their credentials of another system to make the two systems capable of exchanging the needed data and information while running independently and have database secure and access being private from other systems.

The next section briefly introduces the structure and the workflow of ERIC API with the case of integrating Moodle and an online test system, OTS [1]. Section 3 describes the integrated system and Section 4 discusses the benefits of the integration and talks possible future works that can be done later.

2 Workflow of ERIC API

When a student logs in Moodle, the Moodle authenticator has to check whether or not his or her credential such as username and password is correct. To enable the interoperability of Moodle so it can work with other independent system like OTS – an online test system, it needs to store the student's username into session after his or her identity has been verified. Fig. 1 shows how ERIC API works in the integration of Moodle and OTS.

Before a Moodle block (as shown at bottom left of Fig. 1) can ask for the student's test relevant information from OTS and show on the block, Moodle has to get permission from the student so OTS can respond its information access request. To get the student's permission, the client module of ERIC API at Moodle site (i.e., we call service requestor) first retrieves the username from the session and converts it to a specific Universally Unique Identifier (UUID). The client module then redirects the student to the permission granting page of the server module of ERIC API at OTS site (i.e., we call service provider). On the permission granting page, the student has to enter his or her OTS's username, password and select at least one privilege (e.g., allows Moodle to show the tests he or she is supposed to take) that he or she wants to grant for Moodle to access. The server module randomly generates an authorization code and redirects the student back to the service requestor with the confirmation of granted permissions after it verifies the student's identity from OTS' database. As soon as the student confirms his or her authorization via entering the correct authorization code, OTS block on Moodle will be able to send information requests of the granted permissions to OTS and get the data its needs to show on the webpage.

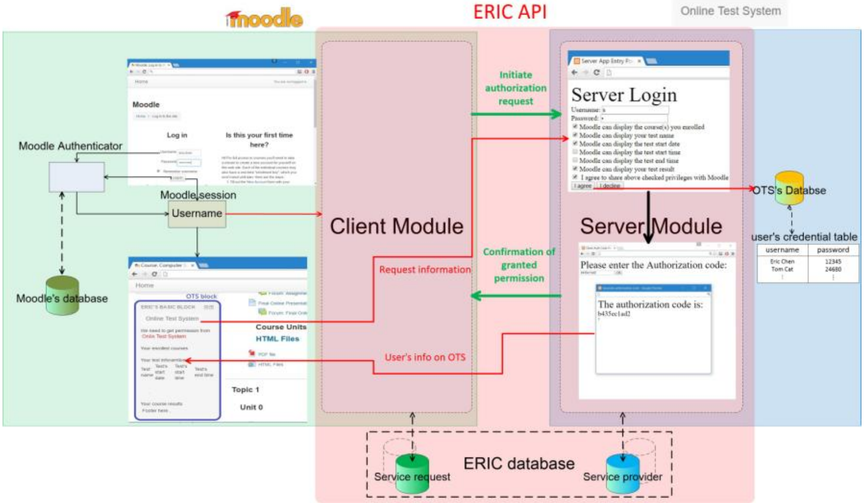

Fig. 1. ERIC API Architecture

3 Case of the Moodle and OTS Integration

In this section, we use a case to explain how a student grants Moodle to access and show the information that he or she has on OTS when the ERIC API is plugged into Moodle. As Fig. 2 shows, when a student logs in Moodle, he or she can see a block on the left side on Moodle.

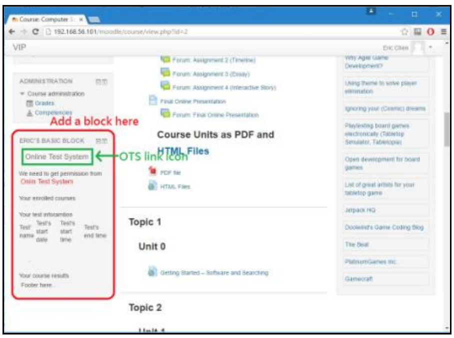

Fig. 2. A Moodle block

The student can click the “Online Test System” link to setup which permissions he or she wants to grant for Moodle to access. Fig. 3 shows he or she allows Moodle to access and show the courses he or she enrolled, the test names and their start dates he or she needs to take, and the performances he or she got.

Fig. 3. Permission granting page at service provider side

Fig 4 shows that the Moodle block now can show the information on OTS that the student authorized it to access via sending requests to OTS with client module of ERIC API.

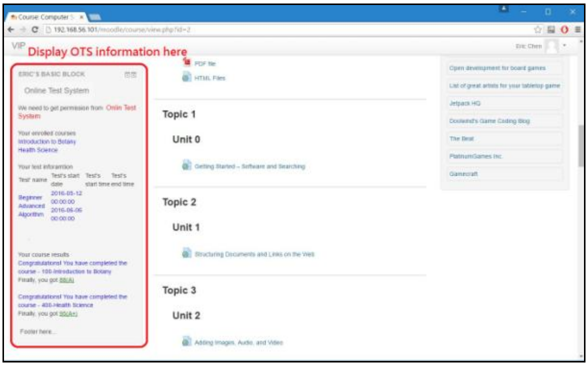

Fig. 4. The Moodle block with built-in ERIC API can now access the student’s information on OTS.

4 Conclusion

The research team developed ERIC API that makes two systems capable of working together without asking users of one system to keep authorizing the system to access the service and the data that the other system offers. Also, ERIC API is developed to provide system administrators quick and easy installation process so they can integrate the services provided by two separate systems with very few efforts. In many cases, educational technology researchers design and develop good technology-enhanced learning systems and tools for administrative personnel, teachers, and students, but then they find that it is very difficult for them to make the stakeholders really benefit from or adopt their research results due to the difficulties, heavy efforts and concerns that the stakeholders may have for integrating the research systems/tools into the existing platform or system they are using. The development of ERIC API can not only make stakeholders be exposed to more useful applications, systems, and tools but also help researchers promoting and testing their research results effectively and easier. Moreover, the research team would like to conduct a pilot to evaluate the effectiveness of ERIC API by collaborating with teachers and schools to test the usability of the integrated systems.

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The Academic Analytics Tool: Workflow and Use Cases*

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Abstract. To meet the demand for timely analysis and revision of online courses, educators need ongoing, unfettered access to data about how students interact with courses and online resources. Currently available tools for exploring student data provide some important insights, but are typically focused on automated data mining, visualizations, or displaying pre-set reports. These tools also often require either high technical skills and/or installation of specialized software, making them inaccessible to most educators and learning designers. In this paper, we introduce the Academic Analytics Tool (AAT) and provide some hands-on examples on how the tool can be used. AAT is designed to allow people (e.g., educators, learning designers, etc.) without technical expertise to extract and analyse data from learning management systems (LMSs). AAT offers high usability and permits full exploration of LMSs' data on any computer with internet access to foster responsive analysis and improvement of online courses.

Keywords: academic analytics · data extraction and analysis · online learning

1 Introduction

Online learning is still a rather new educational option, and there is much to be learned about the best teaching methods and course designs for this format. The multi-year course revision process is simply not conducive to meeting the evolving demands of online students, or rapid changes in the online educational marketplace. To ease the burden on IT departments and ensure courses are monitored and revised frequently and appropriately, educators and learning designers should be empowered with direct access to data about student behaviour in online courses [1].

Learning management systems (LMSs) store vast quantities of data about student activities in their courses, including forum activities, access of online books and resources, grades on quizzes and exams, assignment submissions, and communications with instructors [2]. By analysing this information, educators can learn a great deal about what students are doing in their courses, and what factors affect student success.

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A number of tools exist to extract student behaviour data, but these typically come with limitations that make them difficult for educators to use or they limit the data educators are able to investigate. There is a need for tools designed for educators that allow for a full range of queries on all available data in an LMS, and that work with a wide range of LMSs and database formats [3,4].

The Academic Analytics Tool (AAT) [5] is a software tool designed to allow educators, learning designers and school administrators to perform their own investigations to gain a better understanding of how students interact with online course materials and resources. It is designed specifically for people who do not have experience with database systems or analytical software, and runs on any computer without additional software because it is browser-based.

AAT is different from other tools because it provides no pre-set reports, and does not perform any automated data discovery. Instead, it supports users in their own investigations into any data available in a LMS, using a wizard style interface that can be used by users without programming, analytical or database skills. The resulting reports can be output in a variety of formats to be used in other analysis tools (e.g., statistical tools, advanced visualization tools, etc.). AAT also facilitates sharing amongst users by allowing them to save their projects and results as "public" so they are available to others. Thus, AAT empowers educators and learning designers to better understand what is going on in their courses, responsively revise courses, and monitor the impact of changes to course designs and teaching methodologies.

While AAT can help answer a broad range of questions, a few examples are:

- How many students are using a given resource? Is its use correlated with better performance on exams?
- Are certain types of resources and activities (e.g., quizzes, forums) more helpful for students in one course or faculty than in another?
- How does performance in a junior level course correlate to performance in advanced courses?
- Do students who complete optional quizzes score better on the final exam?
- When teachers are more active in discussion forums, does such behaviour impact students' overall grades?
- When teachers share the best solution of an assignment with the class, does such behaviour impact students' performance on subsequent assignments?

The rest of the paper is organized as follows: section 2 describes how AAT works and section 3 provides a few hands-on examples. Section 4 includes our conclusions and goals for future work.

2 How AAT Works

Every investigation in AAT begins with a *Project*. The rest of the terminology is similarly in plain English, designed to accommodate users without technical backgrounds. For each *Project*, AAT steps users through the process of building a query on the

LMS database using a wizard-like interface. In the following, the basic process/workflow for all AAT investigations is described:

Step 1. Name and save a new *Project*: the *Project* acts as a container to store the selections for a given investigation.

Step 2. Select an LMS: an educational institution may use more than one LMS, but each *Project* is only retrieving and analysing data from one LMS.

Step 3. Select a *DataSet*: the *DataSet* consists of all of the courses that should be included in an investigation. The *DataSet* can consist of one course, several, or all courses. In this step, either a predefined *DataSet* can be selected or a new one can be built from all or any combination of available courses in the selected LMS.

Step 4. Build a *Pattern*: a *Pattern* specifies what should be investigated in terms of *Concepts* (i.e., students, quizzes, forums, etc.) and *Attributes* (i.e., student id, quiz grades, forum messages, etc.). In addition, limits can be added to use a variety of filters (e.g., include only students with quiz grades lower than 70%, etc.). A *Project* can have many *Patterns*. Therefore, many investigations can be performed on the same set of courses.

Step 5. Optionally, additional actions can be performed on a saved *Pattern*, such as *Cloning* (making a copy of a *Pattern* to edit or share), *Chaining* (linking two *Patterns* together to expand the results) and *Analysis* (performing calculations such as average, sum, count, min and max on a result set of a *Pattern* to analyse data in more detail).

Step 6. View the results of a *Pattern*, or export them in HTML, XML, or CSV format for use in other analysis tools, or for sharing with others.

3 Use Cases

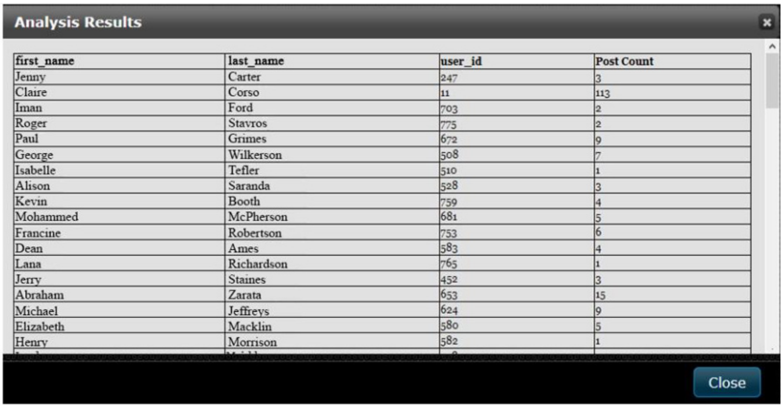
In this section, three simple hands-on examples / use cases are provided to demonstrate AAT's functions and how it works.

The first example shows how a user can find the overall number of forum posts, posted by students during a given timespan (i.e., between March 1 and March 31, 2016) in a given course (i.e., "COMP101").

In order to answer this query, a user first needs to create a new *Project*, select the respective LMS and create a new *DataSet* with the respective course(s) to be investigated (e.g., "COMP101"). In the next step, a new *Pattern* needs to be built, selecting "Student" and "Post" as *Concepts*. Then, the *Attributes* are selected as "forum post id" and "time forum post created" from the POST grouping and "first name", "last name" and "user id" from the USER grouping. To limit the result set to only postings between March 1 and March 31, 2016, a limit on "time forum post created" can be set to be between "March 1, 2016" and "March 31, 2016". Afterwards, the *Pattern* is named and saved. In the next step, to count the number of postings, another *Pattern* is built using the "Analyse" button. The *Pattern* just created is selected from the list of available options as basis for the *Analysis*. Then, an *Analysis* with one value as result is selected and the COUNT of "forum post id" is chosen. To see the result (a single value representing the overall number of forum posts posted by students during the given timespan and in the given course), the *Analysis* can be executed by clicking on the “Perform Analysis” button. As a last step, the *Analysis* should be named and saved to access it at a later point.

The second example illustrates how to find the number of forum posts from students and teachers in a set of courses (i.e., all 1-level COMP courses including COMP101, COMP102, COMP103, COMP104 and COMP105). As output a list with each person’s first and last name, user id, and the number of postings of that person is expected.

To answer this question, again, the first step is to create a new *Project*, select the respective LMS and create a new *DataSet* with the respective courses to be investigated (i.e., all 1-level COMP courses). In the next step, a new *Pattern* is built by selecting “Student”, “Teacher”, and “Post” as *Concepts*. Then, *Attributes* are selected to be “forum post id” from the POST grouping and “first name”, “last name” and “user id” from the USER grouping. No limits are needed for this example. To finalize the *Pattern*, it needs to be named and saved. As a next step, to count the number of postings, another *Pattern* is built using the “Analyse” button. The *Pattern* just created is chosen from the list of available options as basis for the *Analysis* and an *Analysis* with a column as result is selected. Next, the COUNT of “forum post id” for every “User” is selected to retrieve results on how many posts each user posted. To see the result (depicted in Figure 1*), the *Analysis* can be executed through the “Perform Analysis” button. To access the results at a later time, the *Analysis* should be named and saved. To export the results, the *Analysis* pattern just created can be selected, then details are shown about the pattern and when clicking on “Run Project” the output and export options are shown.



first_name	last_name	user_id	Post Count
Jenny	Carter	247	3
Claire	Corso	11	113
Iman	Ford	703	2
Roger	Stavros	775	2
Paul	Grimes	672	9
George	Wilkerson	508	7
Isabelle	Tefler	510	1
Alison	Saranda	528	3
Kevin	Booth	759	4
Mohammed	McPherson	681	5
Francine	Robertson	753	6
Dean	Ames	583	4
Lana	Richardson	765	1
Jerry	Staines	452	3
Abraham	Zarata	653	15
Michael	Jeffreys	624	9
Elizabeth	Macklin	580	5
Henry	Morrison	582	1

Fig. 1. Output of use case 2 – A list of users and their number of forum posts.

The third example aims at finding the average grade on an assignment (i.e., Assignment 1) in different revisions of a course (i.e., COMP201 Revision 1, COMP201 Revision 2, COMP201 Revision 3, COMP201 Revision 4). As output, a list with each course’s name and the average grade on Assignment 1 is expected.

* The figure shows simulated data rather than real student/course data

To answer this query, again, a new *Project* is created, the respective LMS is selected and a new *DataSet* with the respective courses is chosen (i.e., all versions of COMP201). In the next step, a new *Pattern* is built by selecting “Course”, “Student” and “Assignment” as the *Concepts*. Then, the *Attributes* are selected as “assignment name” and “assignment submissions grade” from the ASSIGNMENT grouping, and “course name” from the COURSE grouping. To include only Assignment 1 in the investigation, a limit is set on “assignment name” to be equal “Assignment 1”. Next, the *Pattern* is named and saved. To calculate the average of the assignment grades, another *Pattern* is built using the “Analyse” button. The *Pattern* just created is chosen from the list of available options as basis for the *Analysis* and an *Analysis* is created with a column as result. In the *Analysis*, the AVERAGE of “assignment submission grade” for every “Course” is selected to show the average grade in each course. To see the result of the analysis (a list of courses with each course’s average grade), the *Analysis* can be executed through the “Perform Analysis” button. To access the results at a later time, the *Analysis* should be named and saved. To export the results, the *Analysis* pattern just created can be selected, then details are shown about the pattern and when clicking on “Run Project” the output and export options are shown.

4 Conclusions

This paper presents the Academic Analytics Tool (AAT) and some hands-on examples on how AAT works. AAT empowers educators and learning designers to directly access data from learning management systems about how students interact with their courses, so they can analyse educational outcomes and the impact of changes to courses. Allowing educators and learning designers to conduct their own investigations increases opportunities to monitor the effectiveness of online courses and inform the development of course revisions and new resources. Future work will continue to increase usability for users without computer science skills and offer advanced analytical functions.

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