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Michael E. Auer
David Guralnick
James Uhomoibhi *Editors*

Interactive Collaborative Learning

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Interactive Collaborative Learning

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Preface

ICL2016 was the 19th edition of the International Conference on Interactive Collaborative Learning. This interdisciplinary conference aims to focus on the exchange of relevant trends and research results as well as the presentation of practical experiences in Interactive Collaborative Learning and Engineering Pedagogy.

ICL2016 has been organized in cooperation with the University of Ulster from 21 to 23 September 2016, in Belfast, UK.

Again, outstanding scientists from around the world accepted the invitation for keynote speeches:

- Alaa K. Ashmawy, Dean School of Engineering, American University of Dubai - Vice-President International Federation of Engineering Education Societies (IFEES)
- Marie Céline Loibl, Federal Ministry of Science, Research and Economy Austria -Head of Sparkling Science Program
- Rachel Schroeder, Airbus S.A.S. and Airbus Group - Head of Employment Marketing
- Stephen Lu, David Packard Chair in Manufacturing Engineering, University of Southern California, Los Angeles, CA, USA - Head of iPodia Alliance

Since its beginning, this conference is devoted to new approaches in learning with a focus to collaborative learning and engineering education.

We are currently witnessing a significant transformation in the development of education. There are two essential and challenging elements of this transformation process that have to be tackled in education:

- the impact of globalisation on all areas of human life, and
- the exponential acceleration of the developments in technology as well as of the global markets and the necessity of flexibility and agility in education

Therefore the following main themes have been discussed in detail:

- Collaborative Learning
- Project-based Learning
- New Pedagogies with a focus on Engineering Pedagogy
- K-12 and Pre-university programs
- Learning Culture, Diversity & Ethics
- Lifelong Learning and Academic-Industry Partnerships
- Mobile Learning Environments Applications
- New Learning Models and Applications
- Online Environments and Laboratories
- Computer-aided Language Learning (CALL)
- Real World Experiences and Pilot Projects
- Ubiquitous Learning Environments, Platforms and Authoring Tools

The following submission types were accepted:

- Full Paper, Short Paper
- Work in Progress, Poster
- Special Sessions
- Round Table Discussions, Workshops, Tutorials

All contributions were subject to a double-blind review. The review process was very competitive. We had to review near 400 papers. A team of about 150 reviewers did this terrific job. My special thanks go to all of them.

Due to the time and conference schedule restrictions we could finally accept only the best 130 submissions for presentation.

Our conference had again more than 180 participants from 43 countries from all continents.

ICL2017 will be held in Budapest, Hungary and ICL2018 in Rhodes, Greece.

Michael E. Auer
ICL General Chair

ICL2016

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Andreas Probst[1(✉)], Detlef Gerhard[2], Sébastien Bougain[2], and Christian Nigischer[2]

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Abstract. In Austria a unique research program the so called Sparkling Science has been introduced by the Federal Ministry of Science, Research and Economy in 2007. Within this program, a research collaboration between Technische Universitaet Wien (TU Wien) and several Austrian Federal Secondary Colleges of Engineering (in Austria called HTL) has been set up. This paper gives an overview about the achievements so far including a survey about the impact to daily engineering education.

Keywords: PLM · CAD · V-model · CAx · Engineering education · Engineering collaboration · MBSE

1 Introduction

Research partnership in engineering between vocational schools and universities is supported by the Austrian Sparkling Science program, which was set up by the Austrian federal ministry of Science, Research and Economy in 2007. The aim of this program is to bring science and schools together. One particular goal is to increase the interest for STEM fields (Science Technology Engineering and Mathematics), because there is a significant lack of engineers in Austria and whole Europe as well. Therefore, in this program pupils and students of any Austrian schools are able to work together with scientists and lecturers from Austrian universities and play an active role in research projects. From 2007 to 2016 there have been 198 research projects started [1].

The purpose of this paper is to give an overview about the current research partnership and projects together with TU Wien and some HTLs, as well as to figure out the amount of influence to engineering education practice. Additionally, the aim is to identify the key factors for a successful cooperation in engineering education benefitting both, university institution and the secondary colleges. This paper will also give an overview about the current Sparkling Science research project "Systems Engineering" conducted by the mentioned partners.

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2 Completed Sparkling Science Projects Between TU Wien and Austrian HTLs

Up to this date two projects have been concluded between TU Wien and Austrian HTLs and one is currently in progress.

2.1 Sparkling Science Project BLUME

Due to increasing complexity of product development in industry, curricula at Austrian HTLs have been adopted since 2006 to meet the changed requirements. Besides developing the ability to work in geographically distributed teams, enhanced software tools had to be introduced to education lessons as well. This was realized in the course of the project BLUME (Basis PDM Lern- und Projekt-Umgebung für ganzheitliche Mechatronische Produktentwicklung in German: means learning and education environment for mechatronic product engineering) particularly introducing the Product Data Management (PDM) system Windchill (PTC) as engineering data management backbone for the involved schools. Since a PDM system has to be configured to meet the user requirements concerning usability and support, it took some efforts from the project team members to customize the software tools in order to suit the requirements of collaboration among pupils and schools. For example, templates for individual projects as well as for classroom projects were created and adapted. Furthermore, special video trainings concerning PDM systematic and for using Windchill were created [2].

2.2 Sparkling Science Project PDM-UP

After introducing the PDM system Windchill and adapting it to the needs of engineering education, a subsequent project called “PDM-UP” (UP – Umweltgerechte Produktentwicklung in German means “Design for Environment – DfE” also referred to as Ecodesign or green design) was started. Main targets were to include DfE approaches in vocational education and provide the required IT tools for performing environmental analyses. Despite mechanical engineering education at Austrian HTLs includes approximately 600 h spread over five years, DfE is not part of the design lectures but is demanded form industry increasingly. Thus, a particular goal of this project was also to train students performing environmental evaluation of their design concepts independent of their CAD system in use.

Therefore, additional adoptions for increased usability like enhanced CAD and PDM templates, CAD libraries within Windchill as well as general system configuration were made. Existing CAD design data with defined parameters in a PDM system was complemented with data from environmental databases containing environmental impact indicators in this case indicator for global warming. Indicators like Global Warming Potential (GWP) or Cumulative Energy Demand (CED) [3] could be determined using the software and alternative approaches could be evaluated.

3 Key Factors for Successful Research and Development Partnership

3.1 TU View

For TU Wien it is important to get in touch with its future students. On one hand the different educational programs and research domains are presented. Students can also visit the university and get in touch with scientists when they come to attend a project's workshop. On the other hand, cooperation should introduce the future important topics to future engineers. The earlier STEM students learn or at least hear about these upcoming topics of an engineer's work the better they will be able to adapt or grasp the functioning of it. Such cooperation aims to optimize the learning process.

A key factor to maintain this cooperation along the project is the established PDM environment based on Windchill. Each project member is able to look at the updated project's calendar and can also download presentations or tutorials needed for the execution of his or her tasks during the project time. Furthermore for researchers at TU Wien it is a good way of shaping educational materials and strengthen teaching skills. Different topics or problems like the complexity of the subject can be highlighted.

3.2 HTL View

There are three main aspects for HTLs to cooperate in research projects with technical universities.

Firstly students of technical colleges get information and knowledge about technical universities. Since there are not enough highly qualified engineers entering the labor market this is very important. Also students are able to get in touch each year with scientific work. Often this is a key factor for them to decide whether to continue education at universities or to begin a job in industry.

Secondly HTL teachers have the opportunity to communicate and exchange ideas with TU researchers about new and upcoming techniques and methods of teaching them. Since HTL teachers have traditionally good contact to industry companies and therefore newest trends in industrial development and production, this is a good enlargement of their experiences. Of course this will have an impact into daily teaching practice as well.

The third aspect is the impact to the curricula at HTLs. Being involved in research projects with new techniques and methods gives the opportunity to introduce these aspects into regular meetings of curricula committee which consists of members of Austrian Federal Ministry of Education as well as teachers of Austrian HTLs.

4 Current Project "Systems Engineering"

The current research project "Systems Engineering" aims to deepen the collaboration between the different technical educational institutions in Austria and extend the designing knowledge for the early stages of the product development process with systems engineering methods. While the four participating HTLs have their focus on detailed construction design aspects, approaches for dealing with the increasing product complexity on a higher abstraction level already in the early phases of product development are missing in the curricula. Thus, the main objective of this research project is to sensitize teachers and students for the need of approaches like “Model Based Systems Engineering” (MBSE) and provide methodology know-how to overcome the difficulties of complexity and collaboration. Furthermore, TU Wien is able to get feedback about teaching Systems Engineering methods and approaches from teachers and students of the involved HTLs. Pupils at participating vocational schools are directly involved in the research process of adapting general purpose systems engineering methods to product development challenges.

The already mentioned collaboration platform established in previous Sparkling Science projects is used to allow flawless data exchange between all project participants. In order to allow practical MBSE experience with a state-of-the-art software tool, PTC as a project partner provides the modelling tool ATEGO. ATEGO allows the creation of system models using the Systems Modelling Language (SysML), which is a graphical modeling language based on the Unified Modelling Language (UML). As a guideline for the approach of developing complex mechatronic products the V model stated in the VDI 2206 [4] is utilized to learn the basic methodology. Because the students of the HTLs shall not only learn the theory of MBSE, the project follows the learning-by-doing concept exercised during interactive workshops. The practical task of the students is to develop a model of a 3D printer. Therefore a MendelMax 3D printer serves as an illustrative object. A CAD model of the printer is shown in Fig. 1. Parallel to the work of

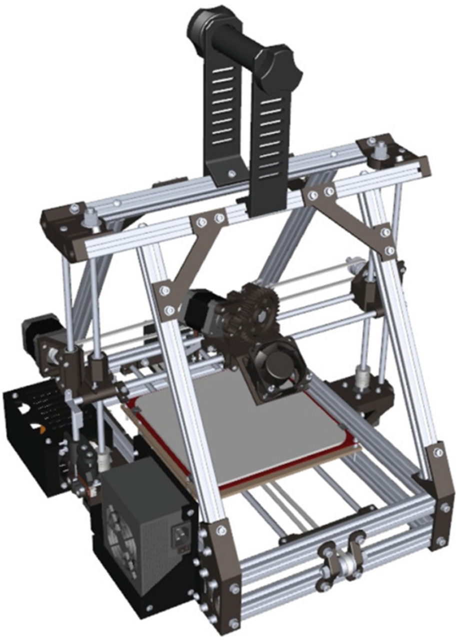

Fig. 1. CAD model of the MendelMax 3D printer

the involved HTLs a SysML model and various improvements are made in the course of bachelor theses at TU Wien. Furthermore, step-by-step tutorials for the usage of ATEGO and the design methodology were generated. At the end of the project, the solutions of the schools and the students of TU Wien will be compared and discussed. There also will be an evaluation of the learning experience and benefits created for all project participants. Additional information about the project “Systems Engineering” can be found in [5].

5 Survey About Research and Development Partnership

5.1 Research Question

To evaluate the main research question “Do the projects of the Sparkling Science program influence the teaching practice in engineering education at Austrian HTLs and the involved persons perception of the program itself?” a survey was conducted in spring 2016. The survey addresses points like knowledge about tasks of current and past research programs, as well as importance of joint research programs over different groups.

5.2 Survey Groups

The first two groups (A + B) include current and former HTL students, the next group (C) contains HTL teachers and the last group (D) includes professors and staff from TU Wien. For these four groups the decision is taken to differentiate between people who have attended and those who have not attended any Sparkling science projects. So there is always a reference group who has only indirect contact to the program through classmates or colleagues. All groups with persons who have participated in research projects contain the number “1” in their group names and all groups with non-participants have the number “2” in their group names. Table 1 gives a brief overview about the different groups in the survey.

Table 1. Overview different survey groups

Overview different survey groups	
Group	Group description
A1	Students who have attended Sparkling Science programs
A2	Students who have never attended Sparkling Science programs
B1	Former Students who have attended Sparkling Science programs
B2	Former Students who have never attended Sparkling Science programs
C1	HTL Teachers who have attended Sparkling Science programs
C2	HTL Teachers who have never attended Sparkling Science programs
D1	TU Professors or staff who have attended Sparkling Science programs
D2	TU Professors or staff who have never attended Sparkling Science programs

Figure 2 shows a summary of 34 answers from students (A1 + A2) and former students (B1 + B2), 27 answers from HTL teachers (C1 + C2) and 7 answers from TU

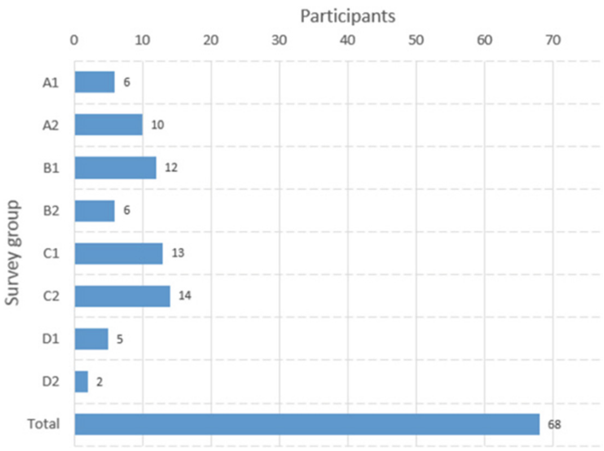

Fig. 2. Survey participants over different survey groups

Table 2. Overview survey questions

Q-Nr.	Survey question
Q1	Gender question
Q2	Which survey group A to F describes your status converning the Sparkling Science programs
Q3	Do you know the Sparkling Science program?
Q4	Do you know the Sparkling Science project "BLUME" with its target to introduce PLM to Austrian HTL?
Q5	Do you know the Sparkling Science project "PDM-UP" with its target to introduce PLM to Austrian HTL in combination with design for environment?
Q6	Do you know something about the tasks and functionality of a PDM system?
Q7	If yes, can you please give some task examples of a PDM system.
Q8	Do you use a PDM system within your design work?
Q9	Do you know the Sparkling Science project "Systems Engineering" with its focus on Model Based Systems Engineering?
Q10	Do you know about the tasks of the reasearch project Systems Engineering?
Q11	If yes, can you please give some task examples of the reasearch project Systems Engineering.
Q12	How impotant do you see the implementation and usage of Systems Engineering within education at Austrian HTL?
Q13	For which tasks or fields within education at Austrian HTL do you recommend Systems Engineering methods?
Q14	Do you see the influence of Sparkling Science research projects general in teaching at Austrian HTL?
Q15	If yes, which criteria could you identify therefore?
Q16	How do you rate the importance of Sparkling Science research projects for the development of teaching content at Austrian HTL?
Q17	How do you rate the importance of collaboration of technical universities and Austrian HTL in Sparkling Science research projects in general?
Q18	Should cooperation within research projects between technical universities, universities of applied sciences and Austrian HTL generally be extended?

professors or TU staff (D1 + D2). Concerning gender aspects there is a distribution of 8.3% (absolute 6) female answers and 91.7% (absolute 66) male answers. All female answers were from students or former students. The average percentage of female students at Austrian HTLs is 16.67% [6].

A number of only 12 responses from former students who have attended recent research programs as well as a number of 6 regular students who are attending the current research program show the difficulty to motivate students to attend such a survey.

5.3 Survey Questionnaire

Though the survey has been done in German language, Table 2 gives a short overview about the asked questions in English.

5.4 Survey Results

Before the first project "BLUME" was conducted, none of the Austrian HTLs touched the topic of product data management in their education. Therefore, introducing this emerging technology was one of the most visible results of the project. More than two-third of the respondents stated that they know the basic concepts and functionalities of a PDM system. Especially the proportion of positive answers from the HTL teachers (C1, C2), even if they did not participate in any Sparkling Science project, is comparatively large. Figure 3 illustrates the results of question 6 in detail.

Question 7 asks for task examples and functionalities of a PDM system. The results show that 87% of people, who stated that they know what a PDM system is, really can

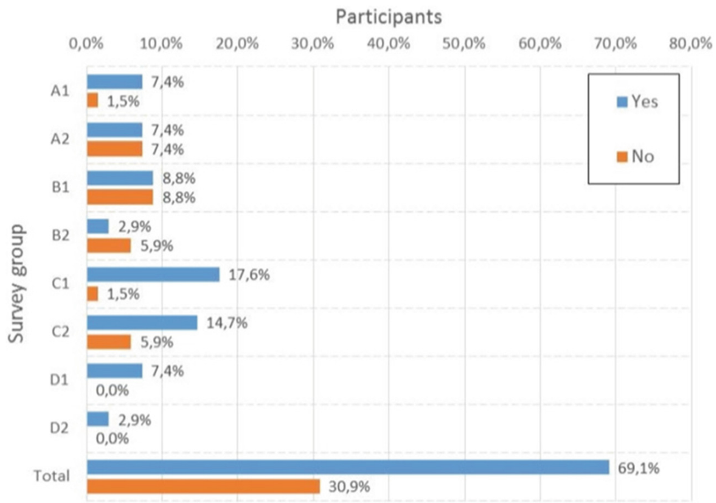

Fig. 3. Question 6 survey results

name and describe various core tasks and functionalities of PDM systems. Strangely people who were not able to give an answer to this question belong to the former students respectively the HTL teachers group who already participated in Sparkling Science projects (B1, C1). The complexity of tasks a PDM system can do may be the main reason for them to not be able to give a short answer. Some even say that nobody could exactly know what a PDM system can do. Further analyses of the survey results reveal that 27% of all respondents, mainly students and teachers from HTLs, not only know core functionalities of a PDM system, but also practically use a PDM system for their constructions. This outcome is quite encouraging to pursue the effort of bringing knowledge about PDM systems to the Austrian HTLs.

Independent of the knowledge level concerning PDM systems, 36.8% of all survey participants actually use a PDM system within their design work. Only the groups A1 and C1, which contain the answers of Sparkling Science project attending HTL students and teachers, have a higher percentage of PDM users than non-users. This can be an indication that the Sparkling Science projects successfully started the introduction of PDM systems in the HTLs. Detailed numbers to question 8 can be found in Fig. 4.

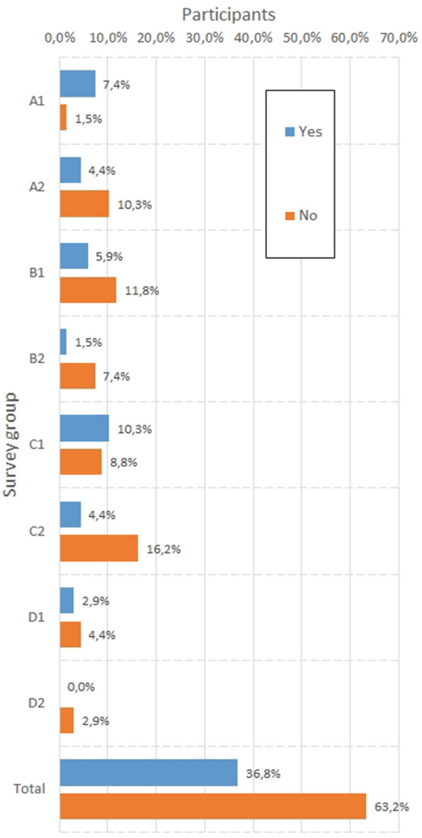

Fig. 4. Question 8 survey results

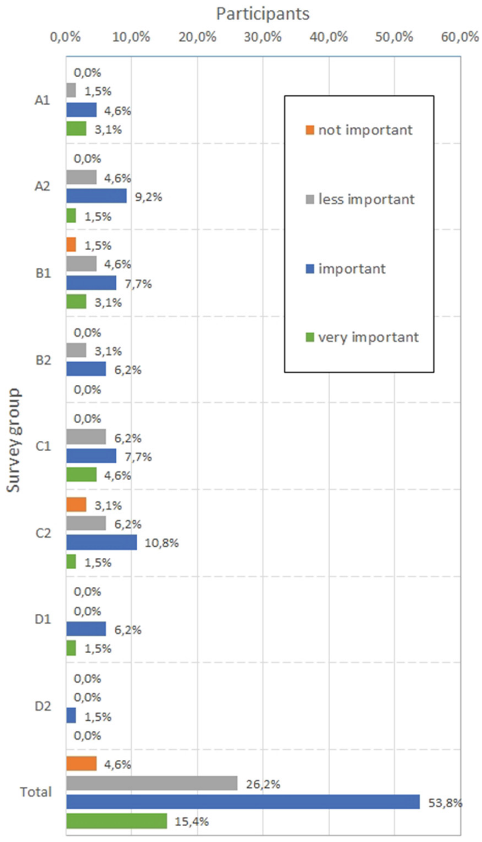

Fig. 5. Question 12 survey results

Asked for their opinion concerning the importance of implementing Systems Engineering into the curricula of Austrian HTL, 69.2% of the survey participants stated that this subject is at least important to them. Only 4.6% think Systems Engineering has no significant impact to education quality of the HTLs. Detailed results can be found in Fig. 5.

Question 13 asks for the fields where Systems Engineering can be advantageous for the students (multiple answers possible). More than 35% of all answers attest students with Systems Engineering increased chances for their career entry. Other important points are the technical understanding of complex products and the ability for inter-disciplinary teamwork. Details are illustrated in Fig. 6.

45.4% of the survey participants think that Sparkling Science projects do not have a significant impact to teaching in Austrian HTLs. Only 29.7% state that Sparkling Science projects have a noticeable influence to the education at HTLs. Mentionable hereby is that HTL teachers who attended in a Sparkling Science project already have the largest proportion of answers that attest at least noticeable impact. Figure 7 shows the detailed evaluation.

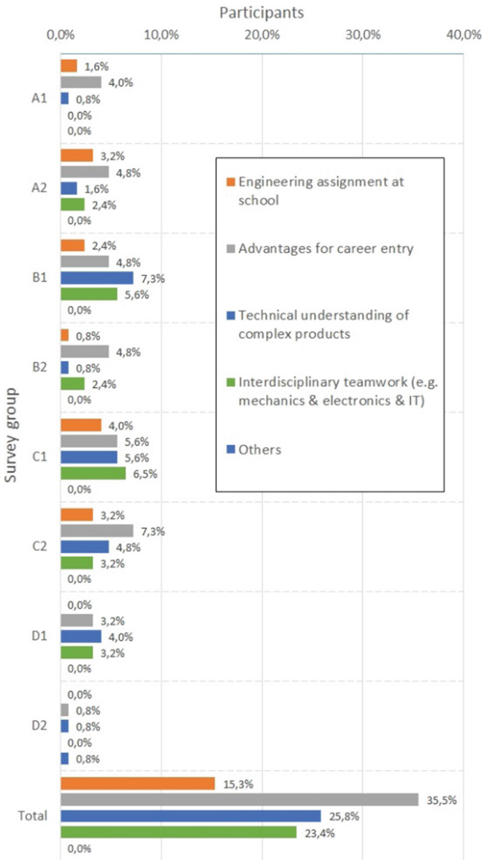

Fig. 6. Question 13 survey results

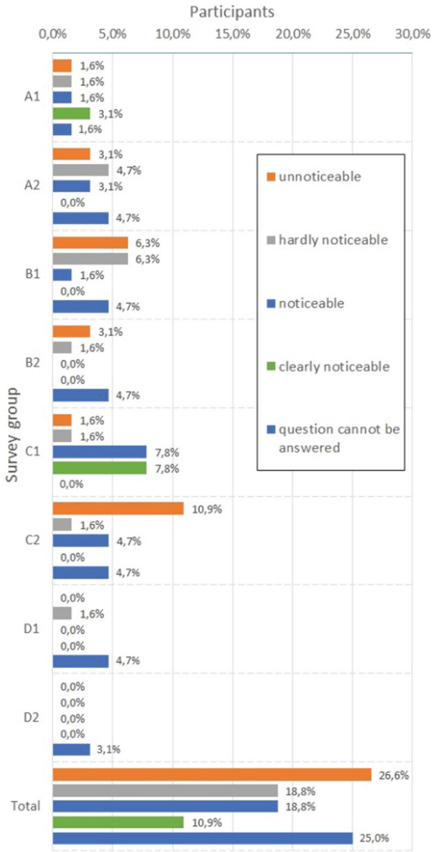

Fig. 7. Question 14 survey results

In contrast to the results of question 14, 65.4% of all survey participants rate Sparkling Science projects as at least important for the development of new teaching content for Austrian HTLs. Only 6.3% think the Sparkling Science program is not important for the education in HTLs. Details are illustrated in Fig. 8.

83.1% of all survey participants rate the cooperation between TU Wien and Austrian HTLs within the Sparkling Science program as important or very important. Especially students and teachers which have already participated in a Sparkling Science project (groups A1 and C1) are convinced of the university-school cooperation. Detailed numbers can be found in Fig. 9.

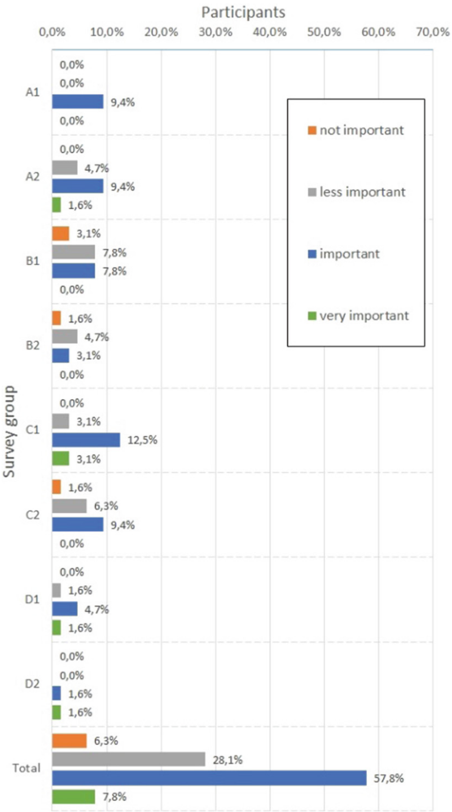

Fig. 8. Question 16 survey results

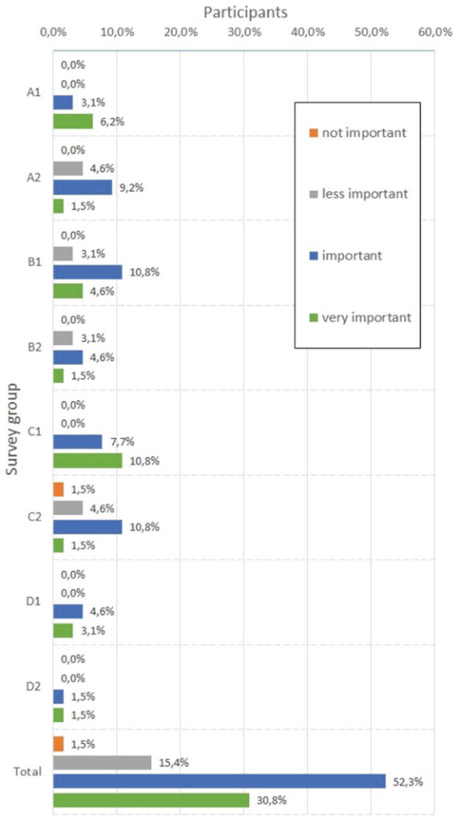

Fig. 9. Question 17 survey results

5.5 Interpretation

Concerning the project "Systems Engineering", people were asked if they know about it and if they can explain the main ideas, concepts, and tool approaches towards systems engineering. As the results shown below in Fig. 10, it is quite clear that people who have participated in a project better know what systems engineering is. Yet people

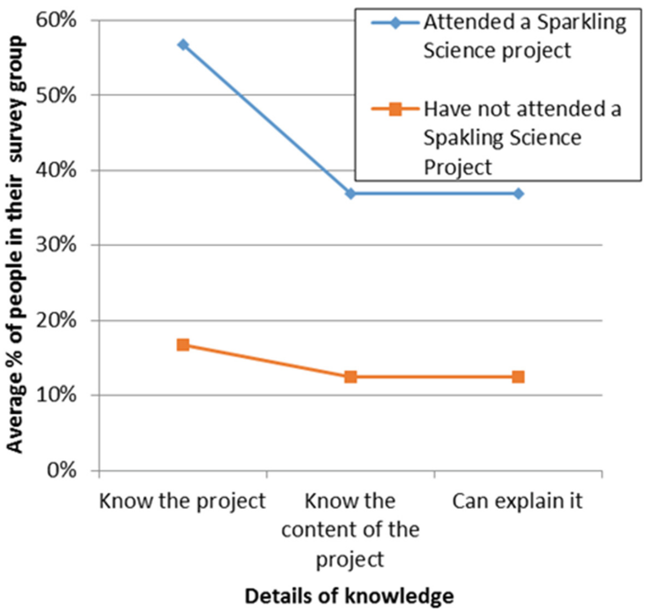

Fig. 10. Different level of knowledge about the project "Systems-Engineering"

who have not participated know less about the concepts of systems engineering. This fact confirms that the project successfully builds knowledge of MBSE in the HTLs. Another interesting point for future researches could be the investigation of success and domains of studies of the people who participated in Sparkling Science projects.

Concerning the open question about PDM systems, an analysis was made about the written answers. In order to keep the grading system simple, people who mentioned the way data is managed (workflow, change management, configuration, etc.) received one point, people who mentioned collaboration aspects (roles, access management, etc.) made possible through a PDM system also received one point. The maximum is 2 points for mentioning both aspects, which indicates strong knowledge about PDM systems, while the minimum of 0 point is associated with weak knowledge. 1 point is interpreted as average knowledge level. By analysing the data structured with the introduced grading system, it seems that people who have attended any Sparkling Science projects are more familiar with PDM systems than non-participants. Almost 38% of the project participants were able to achieve both points, while only 22% of the non-participants managed to reach 2 points. These results show the success of bringing knowledge about PDM systems to the HTLs. Figure 11 illustrates the outcome using the 2 point grading system with the correlated knowledge level.

Considering the knowledge of PDM in the separate survey groups, Fig. 12 reveals that students who are participating in a Sparkling Science project (A1) know a lot more about PDM systems than the ones who don't (A2). But it also shows that over time the students tend to forget about it (B1), or that the teaching got better than it was at the beginning of the program. Further studies will have to be made in order to answer this question.

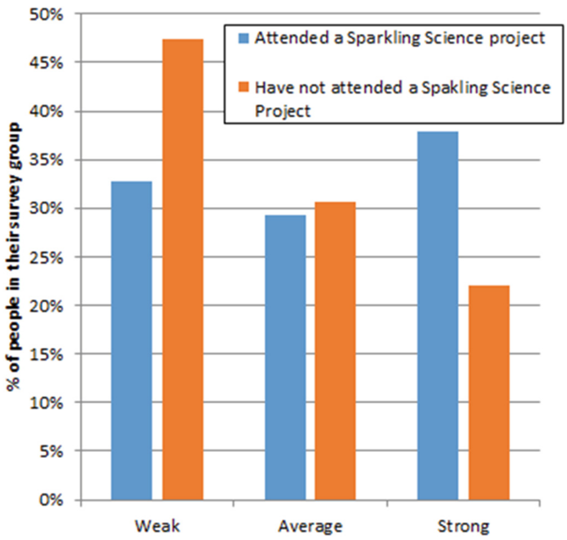

Fig. 11. Different level of knowledge about PDM

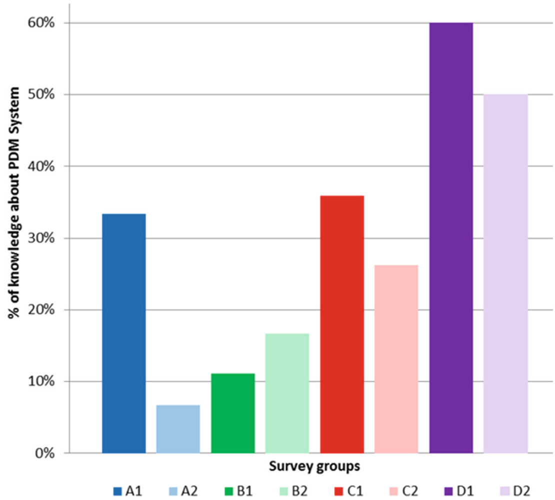

Fig. 12. Distribution of the knowledge about PDM systems over the survey groups

The main influences of the Sparkling Science program were also investigated. According to the survey answers, which are categorized in Fig. 13, the main influence comes from the practical use of PDM systems and the collaboration experience. These two points are followed by the influence of Sparkling Science to the content of teaching materials and finally the influence to different theses that are made through the year. Students are hence learning what a PDM system is, they also use it in order to

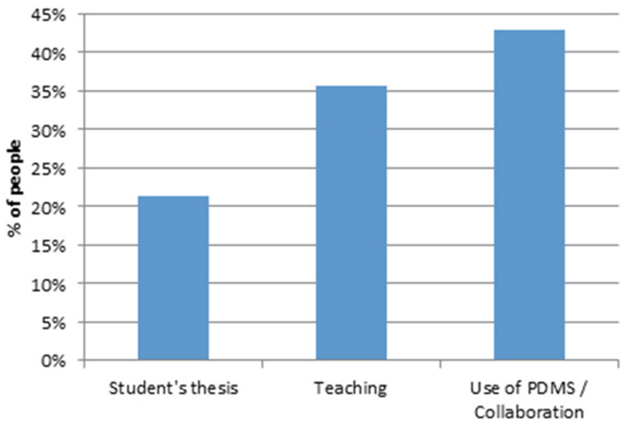

Fig. 13. Influences of the Sparkling Science program

learning-by-doing, and finally if they want a deeper understanding they manage to write a thesis about it. Those influences are very encouraging to pursue this collaboration.

6 Conclusion and Outlook

It seems absolutely necessary to evaluate the knowledge about project topics of all the participants at the beginning of upcoming projects. Additionally an evaluation after finishing the research project to get information about the change of knowledge compared to the project start is necessary too. Evaluation during the running project is an option too. All these information will give enhanced feedback about the performance of upcoming projects. Doing a survey earlier in the research project will increase the number of answers from students who work on the project.

As people were facing difficulties with CAD systems 15 years ago, they are facing problems handling PDM systems today. Model Based Systems Engineering with ATEGO is in an early stage. Feedback during the project highlights the complexity of handling such a new software. This is why some improvements concerning workflow, look and feel as well as interfaces to other programs should be introduced.

Overall, the results from the survey conducted in spring 2016 are a big encouragement to continue the effort of cooperation between HTLs and TU Wien that started nine years ago in 2007. Nevertheless, as already stated above, it would be interesting to perform further investigation in order to know if the introduced projects create additional value over time for the participants.

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Digital Educational Mind Maps: A Computer Supported Collaborative Learning Practice on Marketing Master Program

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Abstract. Mind mapping approach is acknowledged as a fruitful collaborative educational technique. However, there is a lack of researches on students' experience during learning with mind maps. Nowadays, information technologies are developed and wide spread impetuously. Thus digital mind maps become more and more popular. The process of their creation is strongly supported by different software, but little is known about this software application to educational needs. This paper aims to fill this gap. The comprehension of mind mapping approach adoption is implemented in a form of pedagogical reflection. The data for the pedagogical reflection were gained from the research, which was designed in a mixed methodology. The combination of a survey and a participant observation aimed to get collaborative data on students' perception and estimations of mind mapping. The survey's questionnaire was developed based on the technique's functions and results of participant observation. The analysis highlighted that the Coggle may be confidently use as an educational software in case of supporting in-class and home collaborative activities on mind mapping. As a result, the set of recommendations for teaching with mind maps was developed. The directions for a further work are discussed.

Keywords: Collaborative learning · Computer-supported collaborative learning · Mind mapping · Digital mind maps · Mind mapping software

1 Introduction

Mind mapping has become a widely established learning technique [1]. It solves a wide range of educational tasks, e.g., critical thinking development, assistance to memory, rising of students' involvement [1–6].

Furthermore, mind mapping approach is acknowledged as a fruitful collaborative educational technique. However, there is a lack of research on students' experience during collaborative learning with mind maps. Below, we will use abbreviation *MM* for a *mind map*.

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Last two decades rapidly developed information technologies have started a new era of MMs, and brought into life *digital mind maps* (to address one digital mind map we will use *DMM* abbreviation). Evidently, educators, who share an idea of computer-supported learning, have begun to include DMMs into educational routines. As far as the mind mapping approach is quite popular in different areas [2, 4], the processes of DMMs creation are strongly supported by a variety of software.

Collaborative software dissemination made it possible to support educational collaborative processes at the very beginning of 21th century. Moreover, a number of collaborative mind mapping tools were introduced (e.g., *MindMup*[1], *Coggle*[2]). In spite of mind mapping approach and mind mapping software are popular to in-classes routines, little is known about the practice of such tools selection and adoption to educational needs.

Furthermore, any mind mapping tool is a representative of an interactive visualization software, and, consequently, inherits its features. It is known, that researchers highlight potentially ambivalent impact of a visualization software in teaching. This point of view represents the following general weaknesses relevant to a mind mapping tool [7]:

1. it may not meet a student's needs;
2. it may be too time consuming in usage for students and teachers;
3. it may switch the focus from content to visual effects.

Summarizing, the poor documentation of an educational process supported by collaborative mind mapping tools and a huge amount of available software raise several questions on selection and adoption such software to a particular instructional process. The paper contributes into amount of knowledge on the mind mapping approach in learning process. It integrates students' experience, instructional design and learning software perspectives. The research focuses on learning experience both positive and negative, weak and strong points of the mind mapping approach and software, the ways to deal with them.

The paper pursues the following goals:

1. to describe students' experience in learning with DMMs;
2. to introduce the Coggle web-service adoption to support collaborative learning through mind mapping;
3. to discuss DMMs from teaching, learning and educational collaboration points of view.

The empirical base of the research is an observation and a survey during series of seminars for "Consumer Behavior in Global Environment" course with the first year master students of Marketing Program in National Research University Higher School of Economics (HSE). During the course MMs act as a powerful collaborative technique. In order to consider on students' experience and interpret their feedback the pedagogical reflection is used.

[1] http://mindmup.com.

[2] http://coggle.it.

2 The Core of Mind Mapping Approach

The world of visual educational forms is rather rich. We are going to define basic concepts and to overview the core of mind mapping approach in this section.

Tony Buzan has registered a MM as a trademark and defined it as a diagrammatic method of representing ideas, with related concepts arranged around a core concept [8] (Fig. 1[3]). Unfortunately, in our context this definition is a bit confusing, because concept maps [9] in education are as popular as MMs [10]. Despite there is a close relation of these two models, there are number of meaningful differences between them. This difference is studied and discussed in [11].

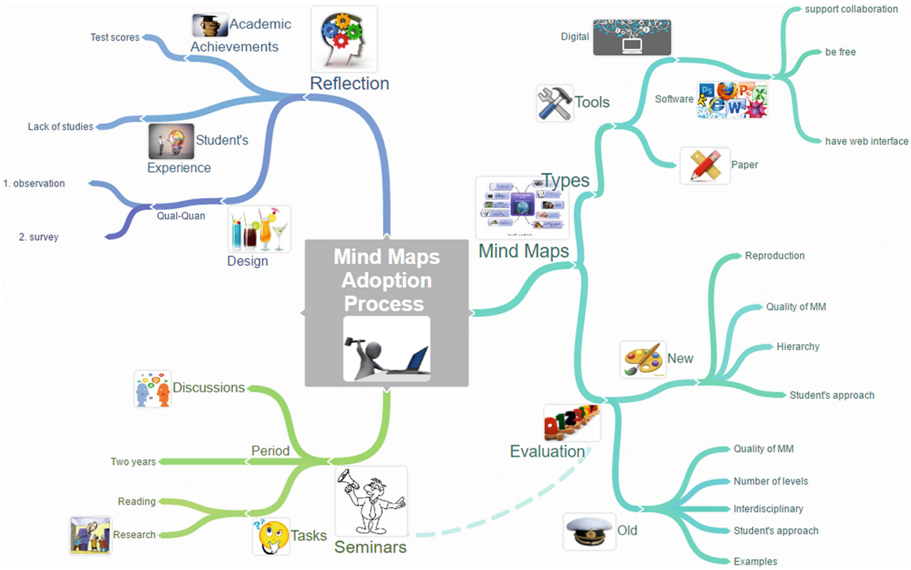

Fig. 1. The mind map of this paper

A MM is a hierarchic graph organized around the central image. An entire subject is divided into a set of categories diverging from the central image. Each notion creates a branch including subcategories and examples logically drawn from the notions. Furthermore, a MM packs information in a logically sustainable way. It also uses colors, figures, fonts, and images. Taken together these features facilitate memorization. Due to analytical work while developing a set of categories and subcategories mind mapping supports understanding, critical thinking, and comparison [4], structuring of a problem to be solved [6]. As a thinking method, mind mapping is a favorable environment for collaborative learning and creative problem solving [18, 21].

[3] The full version of this mind map may be accessed at Google Drive (https://goo.gl/BeHSzT).

From a technological point of view, a MM is represented by a rooted tree of concepts, but this tree has extra features:

1. an additional layer of associations between concepts;
2. a set of concept's visual properties, such as color, figures, images, etc.;
3. an explicit circular layout of MM elements.

In this work we will use the term MM to address a thinking method and its main visual artifact.

The efficiency of MMs application in terms of academic achievements is thoroughly investigated [12–14]. Mind mapping has no discipline boundaries, for a review see [2, 4]. Moreover, this technique rises students' involvement [7], bridges old and new knowledge [7, 8], and even improves learning outcomes [2, 3, 8]. MMs serve as a facilitators and assessment tools [4, 5] and as an approach to design of self-instructional modules [3]. Dhindsa, Makarimi-Kasim, and Anderson [14] found that MMs are perceived as more enjoyable compared to traditional teaching approach, but not significantly different in personal relevance. The current research of mind mapping implementation focuses on academic results or functions executed by this technique, but except rare exclusion [13] there is a lack of attention to students' experience during usage of MM.

3 CSCL Through the Mind Mapping

DMMs have become widely used and investigated teaching technique. Willis and Miertschin [15] study visual educational forms as active learning approaches and concern on MMs and mind mapping approach as powerful learning tools developing critical thinking and problem-solving skills. Jbeili [13] has found a positive impact of DMMs on individual students' science achievements and recommended usage of DMMs for teaching. Circumstantial investigation on visual thinking and visual forms in education is given in by McLoughlin and Krakowski [15]. They have presented methodical recommendations on educational materials and the way of their changing and improving. Furthermore, they have explored the role of information technologies in conducting visual forms of education such as MM.

Collaborative facet of a MM is also a subject of researchers' interest. Koznov and Pliskin in [16] explore the role of MMs in CSCL. They also introduce Comapping[4]. The main disadvantage of Comapping in our case is the absence of a free plan for education. They avoid the discussion of different programs referring to commercial overview of these tools. Wu, Hwang, Kuo, and Huang consider different computer platforms for collaborative mind mapping, mobile gadgets and PC [17]. Vaida, Plotz and Fink focus on machine reading or hand-drawn MMs obtained as a result of a brainstorm session [18]. Liu, Zhang, Tao, Ren, Li, and Du present an online mind mapping tool for integrating and sharing personalized learning resources [19]. Although authors claim the superiority of their product compared to E-learning

[4] http://comapping.com.

systems, they do not analyze existing E-learning systems or mind mapping tools in terms of integrating and sharing needs.

4 CSCL Mind Mapping in "Marketing" Master Program

4.1 Instructional Design

The mind mapping approach was implemented as a part of seminars during the master's "Consumer Behavior in Global Environment" course at the first time in 2014/2015 and repeated in 2015/2016 academic year with the first year students of the same program. We found mind mapping relevant, because this learning technique meets some important requirements of a curriculum:

- bridging courses inside the master program;
- development of student's creativity;
- shaping of critical analysis skill.

The course is a mandatory part of the program studied since 2012/2013 academic year. The course includes lectures and seminars. Formative assessment consists of a mind mapping and an essay. Summative assessment is cumulative and contains a MM and an essay.

The major part of seminars' tasks includes a collaborative component. Students work in pairs and prepare MMs of an outclass reading or results of research tasks. The other important collaborative components are a discussion and an evaluation of MMs in class.

4.2 Course Software Environment

The majority of master students are busy at work and it seems to be reasonable to automatize their learning activities as much as possible. That is why we preferred using DMM and CSCL during the instruction. In this section we speak about software, which was used to support mind mapping in our case.

Criteria of a mind mapping tool selection are developed according to several educational requirements and infrastructure limitations. At first, a desired mind mapping tool is expected to be easily accessible in order to provide remote educational activities of students and a teacher. Thus, we decide to search a tool with web-interface. At second, we need a collaborative tool to support collaborative learning processes. This means that a suitable mind mapping tool has to support group working on a MM, document sharing, commenting, etc. And at last, the *learning management system* (*LMS*) of Higher School of Economics has no plugins or extensions to support learning through mind mapping. So, we can only reckon on free software. Summarizing these three requirements, our ideal mind mapping tool should:

1. support all the significant constructive blocks of MMs;
2. be free;
3. have a web interface;
4. be collaborative.

Following our criteria, we selected a mind mapping collaborative web-service called Coggle. It has several useful to CSCL features:

1. It is possible to collaborate while constructing a MM and to share it, or its parts.
2. A MM can be saved on Google Drive.
3. A MM can be exported to PDF, PNG, TXT and MM file.
4. A MM layout supports an automatic rearrangement and a full branch drag-and-drop.
5. A MM nodes allows to use Markdown markup language and MathJAX.
6. Embedded MMs are permitted and several MMs can be connected by links.

Some of these features and extra technical information are summarized in Table 1.

Table 1. Coggle technical specification.

Feature	Details
Supported browsers	Google Chrome, Opera, Mozilla Firefox, Internet Explorer 11, Microsoft Edge
Export formats	MM, PDF, PNG, TXT
Import formats	MM, TXT
Real-time collaboration	supported
Free plan[a]	supported
Free plan limitations	Maximum image size is 150 × 150px

[a]For the other plans and details visit (https://coggle.it/me)

4.3 Mind Mapping Approach Implementation

In "Consumer Behavior in Global Environment" course mind mapping approach serves as a framework for seminars. Students are asked to represent their homework as MMs weekly. One week there is a reading task, next week a research task takes place.

In terms of content there are two types of tasks: reading and research. Reading tasks are targeted to memorizing and understanding of important categories of the course and critical thinking on these categories. Research tasks concern on implementation of the categories for understanding consumer behavior in the field and developing marketing decisions. In the academic year 2014/2015 the proportion between an individual task and a collaborative task was approximately equal, but in the academic year 2015/2016 in accordance to formative assessment results all the tasks were done in pairs. Pairs were formed by students themselves.

An example of a reading task for a pair: *Choose any article from the list provided for the seminar, read it, discuss and construct based on the article mind map. An example of article: Jillian C. Sweeney, Geoffrey N. Soutar (2001) Consumer perceived value: the development of a multiple item scale. Journal of Retailing. 77. P. 203–220. (doi:*10.1016/S0022-4359(01)00041-0*).*

An example of a research task: *Using participant observation and in-depth interview analyze a consumer's lifestyle and identify its structure. Present results of the task as a MM. Based on the results propose marketing tools.*

4.4 Evaluation

Table 2. Rubrics.

Criteria	Weight, %	Explanation
Number of levels in a MM	20	Each level after a central concept costs 3 points
Interdisciplinarity (reasonable using concepts and theories from the other disciplines)	15	Each category from an external field brings 2 points. Limitations of correctly used categories: not less than 2, but not more than 9
Student's approach	10	Originality, individual approach
Examples	10	1 point for each suitable example
Quality of a MM	30	A student uses adequate images, different colors, and fonts in a MM. If these visualization is missed a student yearns 0 points

5 The Monitoring of Mind Mapping Approach Adoption

The "Consumer Behavior in Global Environment" course has adopted mind mapping for two years as a pilot project. So, each assessment plays a great formative role and is accompanied with a full feedback. This section reveals analysis tool, methods and data collection mechanisms, which were combined in this work.

5.1 Toos and Methods

The comprehension of mind mapping adoption is implemented in a form of pedagogical reflection. Here and after under the pedagogical reflection we will understand a critical reflection, which means that teachers and students play an active role in evaluating and instruction improvement. The impact of critical reflection on learning process and outcomes is concomitantly discussed in [20].

The data for the pedagogical reflection are gained from the research, which is designed in a mixed methodology [21]. This methodology relies on the idea of combining strengths of different methods. The mixture of a survey and a participant observation aims to get collaborative data on students' perception and estimations of mind mapping. According to Preliminary Qualitative Input Design [21] the survey's questionnaire is developed based on learning functions of MMs and results of participant observation. Evaluation of how mind mapping approach performs its learning functions is measured by questionnaire. The participatory observation allows detecting emotions, troubles or some unexpected reactions during the process of the adoptions.

According to Buzen [8] learning functions are helpful in:

1. understanding and remembering learning material;
2. connecting learning material with personal experience;
3. making unexpected suggestions;
4. connecting with other disciplines;
5. in making up something on your own.

Both basic learning outcomes, like understanding and remembering, and complex learning outcomes, like a new knowledge construction, follow from this list of functions.

The participant observation is conducted while presentations of MMs and a discussion on them were going. The participant observation detects student's emotions, questions and discussions on the method. All observed phenomena are documented in a research dairy. The observation results verify Buzen's learning functions and indicate significance of the problem raised in the questionnaire.

Data analysis in mixed methodology inheritably owns triangulation or cross-validation [21]. Quantitative perspective allows formalizing execution of learning functions from student's point of view, whereas qualitative perspective clarifies possible sources of problems and discourage experience.

5.2 Data Collection

General population consisted of the first year "Marketing" master program students of Higher School of Economics (Perm') of 2014/2015 and 2015/2016 academic year. The volume of a research sample was 23 observations. Furthermore, a participate observation was conducted during seminars with students in 2014/2015 academic year. The topic about the implementation of mind mapping in learning process was a part of seminars. During both academic years the survey was conducted at the end of the course. Students were provided with a self-reported pen-and-paper questionnaire at the last class. All indicators were measured in an ordinal scale. The sample differed from the population, because some students were absent, others left the program by the end of the fall semester.

6 Results and Discussion

This research differs from mainstream papers on MM and DMM by focusing on a process of adoption and its unfolding into a set of learning functions and perceived usefulness. The results of the survey show complex perception of the mind mapping approach. The participant observation shows that adoption of the mind mapping approach is strongly associated with a student's motivation. During the adoption of MMs switching costs are an important factor. As MM is a rarely used teaching method in Russian Federation, students are more likely to write an essay or make an oral presentation of some problem solution tasks. For a master program students switching costs are relatively high, what is why during the 2014/2015 academic year a high level of resistance to the method was observed. The participant observation also reveals the importance of a teacher's presentation of the mind mapping approach and instructions on the process of MMs creation. Students cannot see benefits of the mind mapping without credible evidences and success stories.

The participant observation also reveals weak points of assessment of MMs. Highly standardized approach to the assessment was used in 2014/2015. The criteria and their weight coefficients are available in Sect. 4.4, Table 2. The observation shows, that students pursue to meet these requirements, but not to design the best MMs. As a result, MMs often were overloaded, difficult to read and to understand. The next (2015/2016) academic year the assessment system is not that formalized. The new scheme of assessment is represented in the Table 3. The drawback of this approach is a less evident content of criteria. The usage of different weight coefficients confuses students.

Table 3. New Edition of Rubrics.

Criteria	Weights for reading tasks, %	Weights for research tasks, %	Explanation
Hierarchy	20	15	Meeting the requirements of hierarchy structure and volumes of categories
Reproduction	35	15	Meeting the requirement of correct usage of categories, adequate reproduction of learning material
Student's Approach	10	40	Originality, individual approach, categories from external fields
Quality of a MM	30	30	A student uses relevant images, different colors, and fonts. If such visualization is missed, a student yearns 0 points.

The results of the survey demonstrate considerable variance between estimations of execution of different functions. The entire usefulness of the mind mapping is estimated lower, than memorizing and understanding functions. Two waves of the survey demonstrate that students acknowledge usefulness of MMs for understanding and memorizing learning material whereas creative potential of the technic is perceived controversially from year to year.

In evaluation of usefulness of MMs for learning (measured as 0 – absolutely usefulness, 10 – very useful) median is 5.7. Medians for understanding, memorizing are 6.57 and 7 respectively, whereas making up something on your own, connect learning material with personal experience, connect with other disciplines, make unexpected suggestions are 6,43, 5.96, 5.35 and 5. The median of complexity of usage (measured as 0 – very simple, 10 – very difficult) is 6.83.

The learning function "help to make unexpected suggestions" has evaluated with the lowest score. The function "help to connect with the other course materials" is also estimated relatively low (Table 4). The dimensions of a personal relevance and making up something on their own are estimated relatively high.

Another important finding of 2014/2015 academic year is a great role of software in the process of the mind mapping approach adoption. We may consider that Coggle supports all the significant constructive blocks of MMs (e.g. colors, relations, pictures),

Table 4. Overall scores 2014/2015 and 2015/2016.

N	MMs help in learning	MMs help understanding	MMs help in remembering	MMs help to connect with personal experience	MMs help to connect with personal experience	MMs help to make unexpected suggestions	MMs help to connect with the other courses material	MMs help to make up something on your own	How difficult to use MMs	Public presentations usefulness	Year
1	6	6	8	8	5	6	8	5	9	8	2014
2	5	7	7	6	5	5	5	8	8	8	2014
3	8	8	10	7	7	7	8	10	8	9	2014
4	9	7	8	7	6	6	9	9	8	7	2014
5	5	7	9	3	3	5	8	9	10	5	2014
6	7	6	5	5	8	6	5	6	9	6	2014
7	6	8	6	3	3	3	3	6	6	6	2014
8	3	8	6	2	1	1	3	8	8	8	2014
9	7	7	6	7	8	5	7	5	7	4	2014
10	0	6	8	7	5	7	6	0	8	9	2014
11	4	3	7	4	7	2	2	10	7	10	2014
12	6	7	6	7	5	5	7	2	5	9	2014
13	7	8	7	5	3	7	4	3	7	8	2014
14	9	10	10	10	8	8	9	8	8	10	2015
15	8	8	8	7	7	8	9	8	10	8	2015
16	9	9	10	10	10	10	10	7	10	10	2015
17	4	6	5	4	2	3	3	8	6	8	2015
18	0	0	1	1	0	2	2	8	5	9	2015
19	5	7	5	5	6	5	10	7	8	10	2015
20	3	4	4	4	0	6	6	8	7	10	2015
21	6	5	8	7	5	5	5	9	9	9	2015
22	7	8	9	9	7	7	10	7	7	10	2015
23	7	6	8	9	4	4	9	6	8	9	2015
Median	5,70	6,57	7,00	5,96	5,00	5,35	6,43	6,83	7,74	8,26	
Mode	7,00	7,00	8,00	7,00	5,00	5,00	9,00	8,00	8,00	8,00	
MIN	0	0	1	1	0	1	2	0	5	4	
MAX	9	10	10	10	10	10	10	10	10	10	

presents easy GUI for the construction of MMs, supports collaboration, and is accessible through the Internet. Moreover, we suggest the criteria to select mind mapping software for collaborative learning purposes. The short-list of them follows:

1. globally accessed web-service;
2. collaboration (e.g. sharing, group-working) while MM's creation;
3. the most of the constructive blocks of MMs are supported.

In 2015/2016 feedback form is expanded with questions about student's experience in Coggle.

Thus, Coggle is used in learning process in 2015/2016 academic year. The results are tabulated in Tables 5 and 6 contains aggregated data from Table 5.

Table 5. Responses on Coggle usage, 2015/2016.

Question	Responses												
Coggle usability in individual activities	7	6	8	10	1	6	8	1	6	10	2	4	7
Coggle usability in collaborative work	9	6	10	8	3	9	8	7	5	10	4	8	9
Complexity of learning Coggle	6	6	10	10	2	10	8	1	8	8	8	6	7

Table 6. Statistics of responses on Coggle application to learning practice, 2015/2016.

	Median	MAX	%	MIN	%
Coggle usability in mind mapping	5.85	10	15	1	15
Coggle usability in collaborative work	7.38	10	15	3	8
Complexity of learning Coggle	6.92	10	23	1	15

Coggle usability for the mind mapping and collaborative work is measured as 0 – very inconvenient, 10 – very convenient. The median for usability in mind mapping is lower than for usability in collaborative work. It may mean that making MMs students face some problems with the software. The mostly mentioned drawbacks of the software are downloading of images, building of horizontal connection and management of branches. Some students report about problems with zooming, simultaneous access, and accessibility by means of mobile clients. There is criticism of low level of customization, inconvenience for presentation and poor choice of colors and fonts. It should be mentioned, however, that the only trouble with images in Coggle's free plan is a size limitation, and there is no need to download pictures as far as they may be embedded in a MM using a link.

Complexity of learning Coggle is measured as 0 – high complexity, 10 – low complexity. Median for complexity of learning, 6.92 witnesses about low complexity for a half of the sample and high complexity for another half. As median score for usability in collaborative work is 7.38 the conclusion about high usability for collaborative work is proved.

Students consider a practice of presentation and a discussion of MMs as a highly useful activity. The median of this index is 8.26. The benefits of a presentation and a discussion are mainly related to development of oratorical gifts and a structure of thinking. MMs is one more topic for organization discussion into class. The results show that MM suffers from general weakness of an interactive visualization technique [7]. Students cannot recognize DMM as a useful approach. Students find DMM time consuming and difficult to use. Students do focus on a form of a MM instead of content and process of its creation.

7 Recommendations

Summarizing our experience and the results of the investigation we can confidently recommend integrating DMMs into daily educational practices. Of course, this integration should be controlled at both technological and methodological level.

In case of supporting in-class and at home collaborative activities on MMs we may suggest using a collaborative mind mapping web-service Coggle. Among the other functionality, free plan of this service supports all significant features of MMs, has no limitations on quantity of public diagrams, allows to chat and comment.

We also recommend to identify as clear as possible the goal of usage of MMs in learning. Memorizing and understanding is relatively straightforward to manage, whereas solving of creative tasks requires more profound preparation. This preparation lies out of the method as such. It includes break of stereotypes of reasoning and training on generation of new ideas. Particular attention should also be paid to multidisciplinary function of mind mapping. The task should include instructions emphasizing this aspect.

Before a course begins we recommend to estimate students' motivation and their switching costs. This estimation is useful in development of a strategy of presentation and instruction on MMs. The evidence and success stories are helpful for presentation of MMs as a learning tool.

Undoubtedly, MMs cannot be the only learning tool during a course. In order to avoid routinization of mind mapping it is necessary to combine it with other learnings technics. Assessment approach is still an open question. Both more or less standardized approaches to assessment have their disadvantages.

8 Future Work and Conclusion

This work touched two aspects of application mind mapping technique to modern education. At first, we discussed the role of software selection and adoption to educational processes. At second, we explored the methodological features of collaborative digital mind mapping within a particular master course.

The future work on technologies grows from the selected software limitations. Unfortunately, Coggle is a general purposed mind mapping software and it does not support any specific educational activities such as evaluation. Moreover, for today it does not allow to export a MM in a format without information loss, which can be easily parsed by another program. But, this problem may be solved by an extra software, which communicates with Coggle through its powerful API.

The students' experience of collaborative learning with DMM on the marketing master program is described and generalized. Through the results of the mixed research we may conclude:

1. An implementation of DMMs demands attention not only to mind mapping approach, but to supportive software, its introduction and adoption.
2. In spite of Coggle has rich functionality in MMs' creation and collaboration, it is not a fully educational software. So, there is no possibility in using it to evaluate MMs or to support any kind of assessment.

It turned out that perception of usefulness of the mind mapping is differentiated according to its functions. Simpler functions get more positive perception, whereas more complicated ones get less positive. MMs, as well as traditional techniques, may become routine. In terms of instruction and encouraging, usage of MMs is sometimes more complicated than habitual techniques, because its results may not be as visible as habitual techniques' result. MMs are especially demanding to assessment, because of the complex procedure of construction and management goals. The given results show that focus on students' experience opens the dimensions significant for MMs implementation for learning process.

Of course, the results may be a consequence of Russian cultural particularities where more attention is paid to result of problem solution, but not to the process which is underpinned to it. Due to this MMs emphasizing the process are perceived as overwhelming and creating high switching costs.

This research has certain limitations. Firstly, all the estimations are subjective. It raises the question of development objective criteria of estimation of MMs adoption process. Secondly, the sample is quite limited that makes impossible applications results out of it. The results need to be tested on the other samples. Thirdly, the paper considers the evaluation issue of mind mapping not so deep as it deserves. Further search of optimal design for evaluation is also the important direction for future research.

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Applying a Collaborative Learning Technique in PhD Student Groups with Multinational Structure During Foreign Language Studying in Technical University

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Abstract. The paper deals with the research of collaborative learning technique efficiency in communicative competence development in foreign language teaching of PhD students in technical university. The experimental group was engaged in a collective learning organizational form as dominant in educational process. Pedagogical experiment was carried out during "Academic English" language course and demonstrated a high efficiency of certain collaborating learning methods.

Keywords: Collective learning organizational form · Collaborative learning techniques · Communicative competence · Foreign language communication

1 Introduction

In modern education the exchange programs for PhD students from different countries are used increasingly. This results in making up multinational postgraduate groups. The linguistic, cultural and national diversity create barriers that affect both the interpersonal relations and the education progress. Due to such problem, a low efficiency of the traditional learning form becomes obvious [1]. Overcoming the barriers and improving the students' activity are achieved by implementation of the collective learning organizational form (COF) in education process.

The educational process in modern high school undergoes the evolution from teacher centered teaching to learner centered teaching [2] and should be organized in such a way that it would create all the necessary conditions for personal growth and developing the ability to interact with other individuals [3–5], i.e. it is necessary to create a dialogic educational environment. The educational process means not only gaining the information and a professional training, but also a personal growth, acquisition of skills and abilities necessary for efficient interaction with other individuals based on the dynamic social reality [6]. Comprehension of information, perception and understanding of other individuals, as a regulator of appropriate interpersonal relations, developing a socially and professionally adapted personality [7] - this should be a result of shaping the students' communicative competence.

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Application of collaborative learning technique allows one to create the most favorable conditions for PhD students' skills development. Moreover, they learn to handle information, share it with others and receive it from another person both in the native and in a foreign language - and this is the foundation of the communicative competence.

2 Review

A number of Russian scientists researched the competence approach since the second half of the XX century: V.I. Baydenko, A.A. Verbitsky, V.N. Vvedensky, I.A. Zimniaya, U.M. Zabrodin, V.A. Kozyrev, O.E. Lebedev, A.V. Hutorskoy, etc. [8–11].

In other publications a large number of educational experiments which were conducted to research the communicative competence were described [12–14], including the competence approach application in foreign language studying [15–17].

The research team lead by V.V. Rubtsov [18] propose, in our view, the most advanced model of professional competence, which includes five interrelated competencies of an employee:

1. Cognitive competence (formal knowledge, knowledge based on personal experience and understanding of cause-and-effect relationships);
2. Functional competence (technological skills that people working in this field should have and demonstrate);
3. Personal Competence (a set of relatively stable personality characteristics, which is causally related to an effective performance);
4. Sociocultural or ethical competence (building personal opinions, attitudes, social and professional values and the ability to make decisions based on their specific work situations);
5. Metacompetence (integral attribute of social behavior, which includes the ability to communicate, ability to manage with uncertainty, critique, etc.).

Based on this model, communicative competence can be represented as a complex of knowledge, skills, personal qualities, values, abilities to act in certain work situations, the general abilities to communicate. In our study, this model will be applied to the situation of communication in a foreign language.

Changing the objectives and learning outcomes entail modifying the organizational form of teaching methods. Development of personal qualities is possible only in the environment of an interactive learning. One of such interactive forms is the collective organizational form (COF), which is based on the principles of dialog and collaborative learning. In each organizational form, its own techniques and methods of participants' interaction are applied. For the COF these methods are collaborative learning techniques that allow organizing the communication in changing pairs. These techniques include [1, 4, 5, 19, 20]:

- method of additions (text and image);
- method of monitor (text and image);
- method of paragraph-by-paragraph text studying (Rivin);

- method of “opinion polls”;
- method of cooperative trainings (M.A. Mkrtchan);
- operation with theoretical materials through the cooperative topics transfer (V.K. Dyachenko).

The basis of these methods is the interaction in alternating pairs, when students work with each other in the roles of both the learner and the teacher. This learning method involves students in a systematic interaction with each other and forms the ability to cooperate [1]. Furthermore, the barrier due to the difference in abilities is overcome through a mutual explanation and understanding of material. The topic is studied and immediately learned by means of a dialog in a helpful interaction with the others.

The COF theory proposed by V.K. Dyachenko, was researched in the works of A.A. Arhipova, L.V. Bondarenko, O.V. Zapiataya, K.P. Zakharov, V.A. Minov, M.V. Minova, M.A. Mkrtchan, T.F. Usheva and others [1, 19, 20]. The success of the collective learning organizational form is illustrated by many articles, which describe the experience of active learning methods application in the work with groups of different ages: high school, undergraduate and postgraduate students. However, these techniques are not widely applied in the practice of higher education. Thus, the present study is of interest.

3 The Study

3.1 Objectives

The purpose of this research is a verification of the collaborative learning technique efficiency in communicative competence development in the process of teaching a foreign language to PhD students at a technical university.

Main objectives:

1. To carry out a research of a communicative competence development level in a multinational PhD students group.
2. To implement a shaping experiment for the PhD students’ communicative competence development in the English language classes using the collaborative learning technique.
3. To perform comparative diagnostics of the PhD students’ communicative competence development after the shaping experiment.

3.2 Methods

Research methods: theoretical - review of the psychological and educational literature; empirical - observation, testing, and analysis of the activity results; method of data processing - qualitative and quantitative analysis.

Applied techniques:

1. Method of the interpersonal diagnosis of personality (T. Leary).
2. Method of collective psychological atmosphere assessment (A.F. Fidler).

3. A set of testing assignments for determination of communicative competence development level during English language studying in PhD students groups.

3.3 Participants

The research was carried out in the course of “Academic English” with the use of the collaborative learning technique. Two PhD students groups of the first year of studying were selected for the experiment. The first group – experimental – consisted of 12 students, including 4 foreign students; the language proficiency level – Intermediate. Work in this group conducted with the application of collaborative learning techniques. The second group – control - consisted of 12 students, including 4 foreign students; the language proficiency level – Upper Intermediate. Age of participants ranged from 23 to 28 years old. Both courses were presented by highly trained and experienced teachers with equal motivation.

On the lessons, both groups work with the scientific articles with the Upper Intermediate level of difficulty – similar in both groups. Thus, the control group worked within its difficulty level, whereas experimental group worked with materials with an increased difficulty level.

4 Data Collection

Research was carried out in several stages:

- 1st stage (November 2015 – January 2016) – analysis of theoretical material and development of the learning process methodological base.
- 2nd stage (February 2016) – carrying out the diagnostics of the communicative competence initial level development in both groups.
- 3rd stage (February – April 2016) – conducting of pedagogical experiment.
- 4th stage (April 2016) – carrying out of the final diagnostic.
- 5th stage (May 2016) – the processing and interpretation of data.

At the stage of pedagogical experiment, lessons of the “Academic English” course in the control group were conducted according to traditional scheme, and consisted of systematic work with texts (reading and writing assignments) and the development of speech and linguistic skills (listening and speaking assignments). Reading and writing assignments included the independent studying of material and writing of summary that reveals the main idea of text. Listening and speaking assignments included the standard dialog assignments for constant pairs of students.

The techniques, which were applied to research in the field of communicative competence level development in experimental and control groups, are given below.

4.1 The Interpersonal Diagnosis of Personality (T. Leary)

The interpersonal diagnosis of personality technique is intended for research of person's perception about himself and his relations with other individuals in small group. The first survey was conducted at the second lesson when students had worked with each other for some time and had an opportunity to become familiar with other group members. The second survey was conducted at the last lesson of the course. From these test results, it is possible to make a conclusion about the expressiveness of the type and the adaptation degree of a person's behavior in group. The PhD students were asked to fill a questionnaire, consisting of 128 evaluative judgments.

The results were processed in order to obtain the 8 basic indices of characterological tendencies, each one having three degrees of expression: authoritarianism (I), self-sufficiency (II), aggressiveness (III), suspiciousness (IV), subordination (V), dependence (VI), friendliness (VII) and altruism (VIII).

Maximum level of tendency – 16 points. The degree of expression is divided into 4 levels: 0–4 points – low level, 5–8 points – middle level (both means adaptive behavior), 9–12 – high level (extreme behavior), 13–16 points – extreme level (meaning pathological deviations in behavior).

The questionnaire is completed based on the principle of reflected perception, i.e. students should note only those items that do not match their own opinion about themselves, but match the way, *according to the student's opinion*, their classmates appreciate them.

4.2 The Collective Psychological Atmosphere Assessment (A.F. Fidler)

The collective psychological atmosphere assessment (A.F. Fidler) was applied to assess the PhD students' psychological atmosphere. The first survey was conducted at the second lesson when students had worked with each other for some time and had an opportunity to become familiar with the other group members. The second survey was conducted at the last lesson of the course. The PhD students were asked to complete a table in which 10 antonymic pairs of words, describing the interpersonal relations, were presented: friendliness – hostility, agreement – disagreement, satisfaction – dissatisfaction, productivity – unproductivity, warmth – coldness, cooperation – inconsistency, mutual support – malevolence, enthusiasm – indifference, interest – boredom, successfulness – inefficacy.

The 8-point scale was used for assessment. The final index varies from 10 (corresponds to the most positive assessment) to 80 (corresponds to the most negative assessment). Cooperative index of the entire group is the average index of all personal indexes of participants.

4.3 Evaluation of Reading and Writing Skills

Evaluation of reading and writing skills level was carried out at the first lesson in both groups according to the traditional scheme, through studying a thematic Upper

Intermediate level text and writing a summary (4–5 sentences) relaying the main idea of the text. The maximum time given to complete the assignment was 20 min.

Starting from the second lesson, reading and writing assignments in the control group were performed by the students independently. The experimental group members performed the reading and writing assignments in alternating pairs with the help of the method of paragraph-by-paragraph text studying – reading each paragraph and headlining it in one sentence. After the whole text had been segmented and headlined in this way, each student had to write a summary independently, using the obtained headlines list.

The results of completing the assignments were evaluated by the following criteria: the ability to identify the main idea of the text, the ability to operate with the linguistic units and to select synonyms, the ability to write complex sentences.

- The main idea of the text is identified, an extensive lexicon without a frequent iteration of linguistic units is used, complex and multistage sentences are used – 3 points;
- The main idea of the text is identified, a lexicon with some iteration of linguistic units is used, medium complexity sentences are used – 2 points;
- The main idea of the text is identified, a lexicon matching the original text is used, structure of the sentences partially or completely matches the structures of the original text – 1 point;
- The main idea of the text is not identified – the assignment is evaluated as failed, 0 points.

4.4 Evaluation of Listening and Speaking Skills

An evaluation of listening and speaking skills was carried out in both groups with the help of dialog assignments, which required a students' interaction in pairs. The following technique was applied: with the help of prepared cards with several variants of dialog continuation, students were prompted to initiate a conversation, choose response style, appropriate to the situation (colloquial or academic speech), and then continue the dialog in a few responses from each participant.

The assignments were evaluated by the following criteria: correct definition of the situation and choice of communication style, occurrence of difficulties in subsequent interaction, the number of additional responses provided by each participant.

- Correct definition of communication style, no obvious difficulties in subsequent interaction, 4 or more additional responses were provided by the student – 3 points;
- Correct definition of communication style, minor difficulties in subsequent interaction were observed, 2–3 additional responses were provided by the student – 2 points;
- Correct definition of communication style, significant difficulties in subsequent interaction were observed, 1 additional response was provided by the student – 1 point;

- Incorrect definition of communication style, no additional responses were provided by the student – the assignment is evaluated as failed, 0 points.

5 Data Interpretation

5.1 The Interpersonal Diagnosis of Personality (T. Leary)

Comparative diagrams of characterological tendencies show the variation in the experimental group (Fig. 1) and in the control group (Fig. 2).

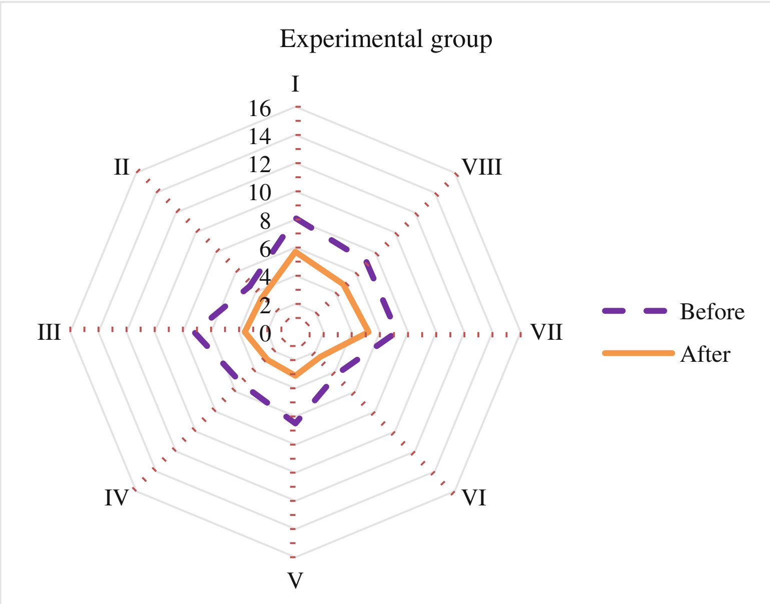

Fig. 1. Characterological tendencies variation in the experimental group before and after the shaping experiment: authoritarianism (I), self-sufficiency (II), aggressiveness (III), suspiciousness (IV), subordination (V), dependence (VI), friendliness (VII) and altruism (VIII)

The diagrams show that the expressions of characterological tendencies before the beginning of the shaping experiment among the students of the experimental group were in the zone of middle values. The indicators of “Authoritarianism” (8.1 points), “Aggressiveness” (7.2 points), “Friendliness” (7.1 points) and “Altruism” (7.1 points) are more prominent in comparison with the other characteristics.

After the completion of the developing experiment, the values of all tendencies decreased, and disposed in a low value range or around the lower boundary of the middle values range. The indicators of “Authoritarianism” (5.7 points), “Friendliness” (5.2 points) and “Altruism” (4.8 points) still have the greatest expressiveness in

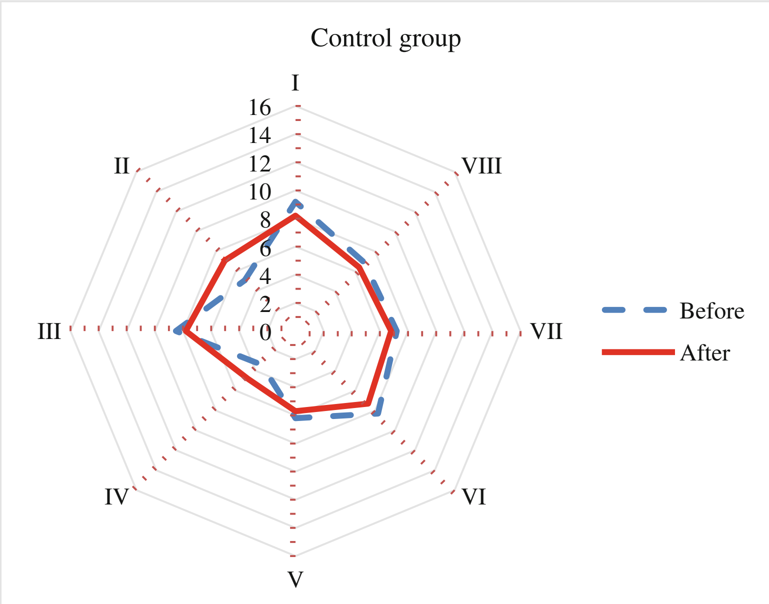

Fig. 2. Characterological tendencies variation in the control group before and after the shaping experiment: authoritarianism (I), self-sufficiency (II), aggressiveness (III), suspiciousness (IV), subordination (V), dependence (VI), friendliness (VII) and altruism (VIII)

comparison with the other characteristics, but they are disposed within the boundaries of an adaptive behavior, which indicates the energy, the tendency to cooperation, and a sympathetic relation to the classmates.

Among the students of the control group, the expression of characterological tendencies are mostly located in the zone of middle values. The indicator "Authoritarianism" stands out as the most expressed one (9.2 points). It can be assumed that among the participants of the control group, there are many students with significant (even prominent) leadership qualities, which could lead to a conflict situation if collaborative skills were not built.

After the completion of the developing experiment, the values of most of the tendencies decreased, but not significantly. 6 of 8 tendencies indicators were disposed around the upper boundary of the middle values range, and hence, there is a possibility that the behavior within the group could go beyond an adaptive behavior. It should be noted that such indicators as "Suspiciousness" and "Self-sufficiency" grew from 3.4 points to 4.8 points and from 5.1 points to 7.1 points, respectively. It can be assumed that among the participants of the control group, during the developing experiment, the aspiration to rivalry was developed more than the aspiration to cooperate. Therefore the classes conducted according to a traditional scheme are ineffective in creation of an optimal learning environment, comfortable for the students, and in promotion of a harmonious development of international relations.

5.2 The Collective Psychological Atmosphere Assessment (A.F. Fidler)

Comparative diagrams show the psychological atmosphere variation in the experimental group (Fig. 3) and in the control group (Fig. 4).

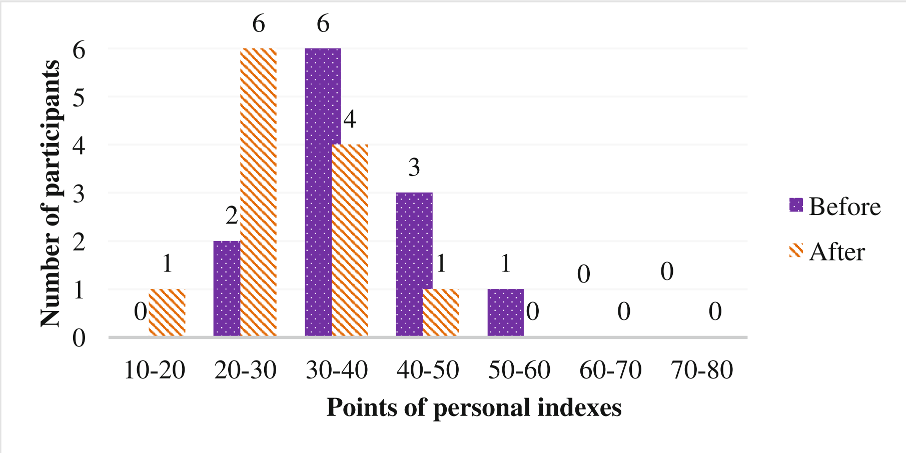

Fig. 3. Psychological atmosphere variation in the experimental group before and after the shaping experiment

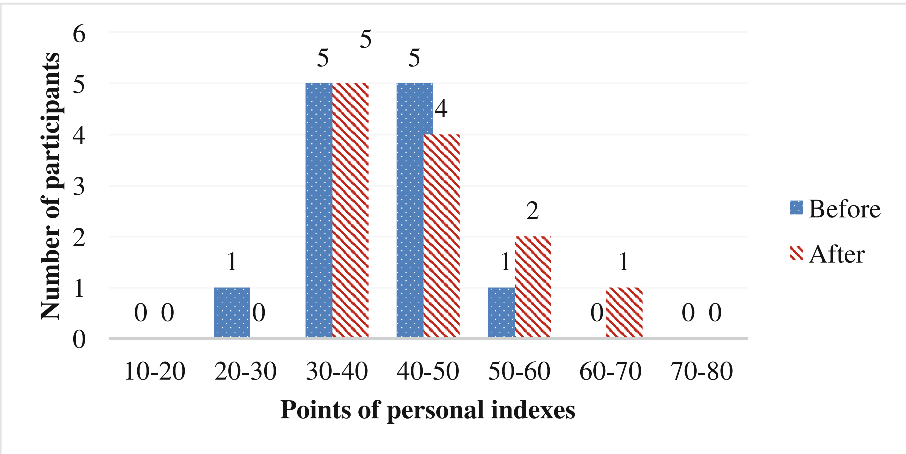

Fig. 4. Psychological atmosphere variation in the control group before and after the shaping experiment

The results show that the psychological atmosphere and the relations between the PhD students in the experimental group have significantly improved. On the average the group index decreased from 35.8 points to 28.1 points. In contrast, the average index in the control group grew from 37.5 points to 44.1 points, which can be indicative of a degradation of the psychological atmosphere in the group.

5.3 Evaluation of Reading and Writing Skills

At the initial stage of the experiments, the reading and writing assignments were completed according to the traditional scheme and showed the following results. PhD students in the control group worked with the text and wrote the summary independently. Some of them completed their assignments sooner, some did later, which is indicative of a difference in skills levels even within one group. However, the time limit was not exceed, and the students demonstrated an expected skills level.

In contrast, PhD students in the experimental group working in accordance with the traditional scheme exceeded the time limit overwhelmingly. This group demonstrated lower results, in comparison with the control group.

Starting from the second lesson the control group continued to work according to the traditional scheme, whereas the collaborative learning techniques were applied in the experimental group. PhD students of the experimental group were instructed to work in alternating pairs, not only reading the text, but also discussing it paragraph-by-paragraph with their partners in English and jointly headlining the paragraphs.

It is worth mentioning that in the beginning, after hearing the rules by which the group would have to work, the graduate students reacted negatively, unwilling to move from place to place and change partners. The work with the first paragraph was slow, however, with each new move and changing of partner, PhD students were working with an increasing interest and enthusiasm.

The next part of the assignment – writing of summary - did not cause any difficulties and took about 5 min. The time limit was insignificantly exceeded, however, all PhD students completed their assignments approximately at the same time, and the quality of their summaries was not much lower than that in the control group, which is indicative of the effectiveness of the technique, even at the initial stages.

Comparative diagrams show the reading and writing skills level variation in the experimental group (Fig. 5) and in the control group (Fig. 6). Results from 9 to 12 belong to 4 foreign participants in each group.

As can be seen from the diagrams, none of the participants of the experimental or control group had their reading and writing skills weakened. In the experimental group almost all participants improved their skills significantly, which demonstrates an effectiveness of the technique.

5.4 Evaluation of Listening and Speaking Skills

Comparative diagrams show the listening and speaking skills level variation in the experimental group (Fig. 7) and in the control group (Fig. 8). Results from 9 to 12 belong to 4 foreign participants in each group.

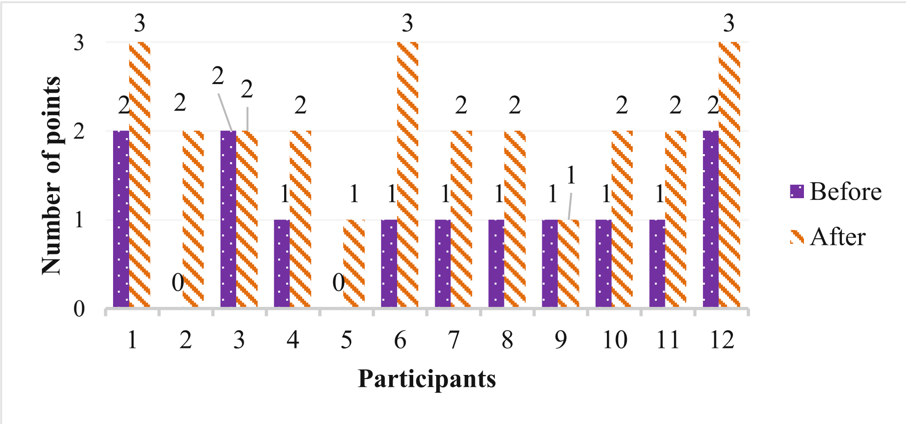

Fig. 5. Reading and writing skills level variation in the experimental group before and after the shaping experiment

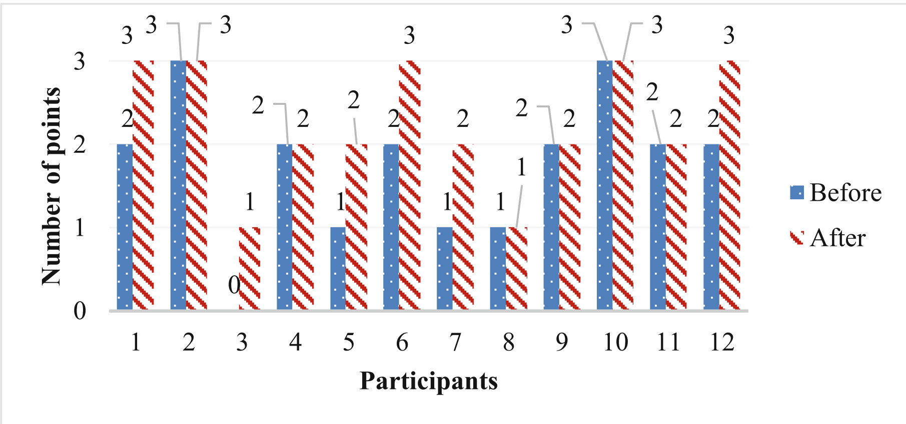

Fig. 6. Reading and writing skills level variation in the control group before and after the shaping experiment

As can be seen from the diagrams, the PhD students of the experimental group have significantly improved their listening and speaking skills. It should be noted that the dialog assignments were directly related to communication, and for the PhD student in the experimental group those assignments posed less difficulties with every new lesson, whereas the PhD student in the control group could successfully cope with the dialog assignments only with their usual partners.

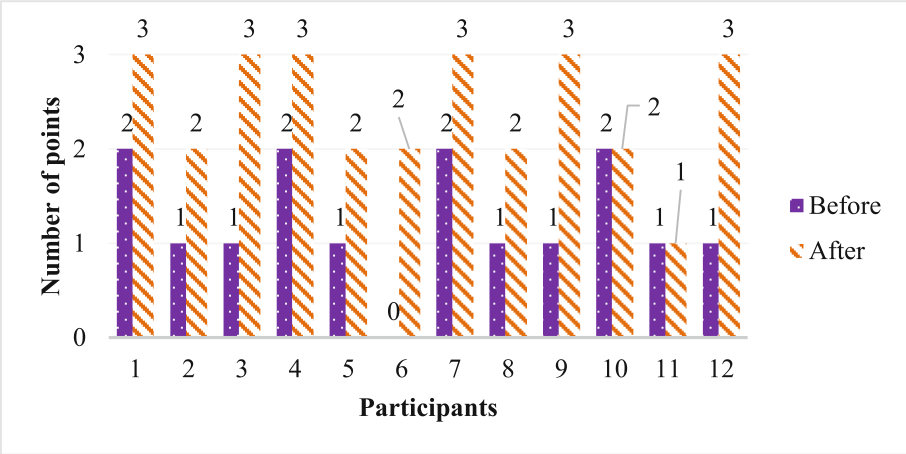

Fig. 7. Listening and speaking skills level variation in the experimental group before and after the shaping experiment

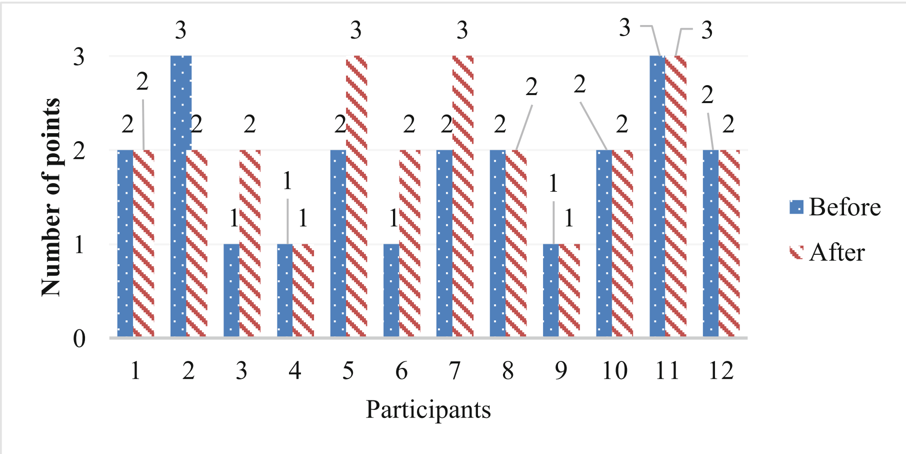

Fig. 8. Listening and speaking skills level variation in the control group before and after the shaping experiment

6 Results

Implementation of the collaborative learning technique contributes to enhancing the development level of cognitive, functional, personal and sociocultural components of the communicative competence in foreign language communication between the PhD students. After a few classes, conducted with the use of the collaborative learning technique, the PhD students in the experimental group could successfully cope with the assignments and learning material intended for groups with a higher level of language proficiency, which is indicative of the efficiency of the technique.

Improvement of interpersonal relations and creating a more favorable psychological atmosphere in the group is marked. Observation of the foreign students showed that in the experimental group those students were involved in a significant interaction with their classmates and entered in communication with the teacher more easily than in the control group.

7 Conclusion

Application of the collaborative learning technique in the English language teaching in the system of postgraduate education contributes to enhancing the development level of the cognitive, functional, personal and sociocultural components of communicative competence, as well as improves the interpersonal relations and helps create a more favorable psychological atmosphere in the group. Under such conditions, the foreign students easily adapted to learning and got involved in the interpersonal communication with their classmates. Thus, the collaborative learning technique enabled establishing a cohesive, initiative and friendly group of students.

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Problem-Based Learning Approach to Teach Printed Circuit Boards Test

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Abstract. This article presents a return of experience of a collaborative educational approach put in place to build a new course about the test of Printed Circuits Boards (PCB). This course was dedicated to 5th year engineer apprentice students from Montpellier Polytech School. The teaching method followed the "problem-based learning" (PBL) approach, which is a student-centered pedagogy: the students learn in-group about a topic (knowledge and know-how) through the experience of solving an open-ended problem proposed by the teacher. This approach targets two types of objectives: technical with the learning of PCB test methods and educational with the learning of thinking strategies, decision-making, negotiation and collaborative work. A course evaluation form has been created, based on the F2A Louvain University one, to help the students providing classifiable feedback about this "problem based learning" approach.

Keywords: Problem based learning · Collaborative · Education · Evaluation · Skills · Competencies · PCB test · Risk analysis

1 Introduction

In 2014-2015, a new course relative to printed circuit boards (PCB) testing has been added to the syllabus of the 5th year Embedded Systems curricula of Polytech Montpellier engineering school. 5th year Embedded Systems students are engineer apprentices students who, since the 3rd year at Polytech school, spend half of a month attending courses and studying and, the remaining half working for a company. In order to position them in a teaching context close to their real world working, the teacher freshly trained to problem-based learning approach from Louvain University teachers [1] decided to apply this student-centered pedagogy to the PCB testing course. Students would learn in-group about a topic (knowledge and know-how) through the experience of solving an open-ended problem proposed by the teacher. The choice of the problem-based active teaching approach was appropriated to motivate the students elaborating a learning strategy where they were protagonists of their learning and the teacher's role was only to guide them to be skilled before the visit of a PCB manufacturing and test plant organized in order to compensate the lack of lab material for practice.

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This paper presents a return of experience of the "problem based learning" (PBL) approach developed to teach PCB testing and is composed of several sections. Section 2 is dedicated to the description of the context of PCB manufacturing and test. Section 3 briefly introduces the Electrical Engineering department of Polytech Montpellier engineering school. Section 4 presents the problem-based learning approach concepts, its process phases, its organization and the impacts on the teacher's role. Then Sect. 4 describes how the PBL concepts have been applied to the PCB testing course and the technical and pedagogical objectives. Section 5 presents the outcome of this new student-centered teaching method while the Sect. 6 states about the required preparation to implement this collaborative approach and the improvements that could be applied. Section 7 is the conclusion of this return experience of collaborative learning and the perspectives.

2 Printed Circuits Boards Manufacturing and Test

A printed circuit board (PCB) is a thin board made by combining different sheets of non-conductive material like fiberglass, composite epoxy, plastic or other laminate material that easily holds copper circuitry. The conductive pathways are etched or "printed" onto board, connecting different surface-mounted and socketed components on the PCB, such as transistors, resistors, and integrated circuits (IC).

PCBs manufacturing first requires designing the board with CAD tools and then fabricating it through several chemical operations.

PCBs are used in both desktop and laptop computers. They serve as the foundation for many internal computer components. Even if PCBs are often associated with computers, they are used in many other consumers' electronic devices like TVs, radios, digital cameras, cellular phones, and tablets and all of them include one or more printed circuit boards. Figure 1 shows the photograph of a PCB with soldered components.

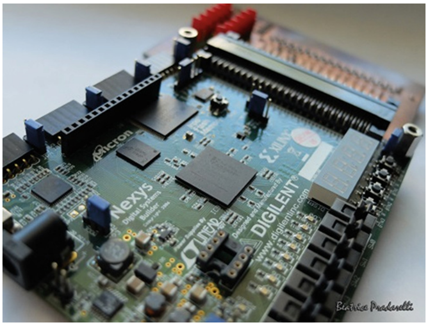

Fig. 1. Photograph of a mounted PCB

PCB testing targets several objectives and happens at different stages of the board manufacturing. Only the main tests are briefly described here. The first test consists in verifying that the naked printed circuits (before soldering any component) are free of any damaged conductive pathways and missing printed note-pad. Verifying the soldering process is part of the second test as well as checking the soldered components presence, value, polarization and alignment. This step of verifications is performed either with an AOI (Automated Optical Inspection) machine or an AXI (Automated X-ray Inspection) one, which both scan every PCB going of the soldering process. Then, an electrical test is executed using a bed of nails or a flyer probe tester to check voltages between nodes. Each of these tests requires dedicated method and test equipment.

3 Embedded System Engineer Students @ Polytech Montpellier

Polytech is an engineering school inside the University of Montpellier, which offers to students starting their 3rd year of study in the Electrical Engineering department, the choice between 2 curricula: "MEA" (Microelectronics Electronics & Automation) and "ES" (Embedded Systems). The students who will select the "ES" curricula will become apprentice students during 3 years and will spend half of a month attending courses and studying and, the remaining half working for a company. The students who will choice "MEA" curricula will be full time studying at the school.

Both future engineers will be able to work in the same fields like the consumers' electronics, automotive, air space and military ones but at different levels: "MEA" engineers will deal with integrated circuits and "ES" engineers will manage systems (from PCB to satellite).

4 Problem Based Learning Approach

4.1 Choice of the Teaching Approach

In 2014–2015, a new course relative to the test of printed circuit boards has been added to the syllabus of the 5th year Embedded Systems curricula. To get students fully skilled in this discipline, it was necessary to provide them knowledge from lecture and know-how from labs. Unfortunately, no test equipment (bed of nails, AOI or AXI) that would have allowed students acquiring practise in PCB testing technics was available at the school. To compensate this lack of lab material, the teacher organised the visit of the Company OMICRON [2] located nearby Montpellier, which was a PCBs manufacturing and test plant. To benefit from the learning of this visit, the teacher wanted the students to know the basics about PCB testing in order to be active and ask questions during the company tour.

Because "ES" students are apprentices working for a company half of their time, the teacher chose Problem-Based Learning (PBL) approach to set up the course into a teaching context close to their real world working. Students would learn in-group about PCB testing through the experience of solving an open-ended problem proposed by the teacher. The challenge was to motivate the students collaborating to define in-group a learning strategy that would have promoted individual and teamwork and achieve the learning objectives. The teacher's role was only to guide them to get skilled.

4.2 Educational Approach Organization

Dedicated course syllabus and training material have been elaborated to match the PBL approach (based on the FA2L Louvain teacher's manual), which basis consists of two sessions of collaborative work and time in between (2–3 weeks) during which students study individually.

The 12 h of the course were distributed as follow: 4 h for the PBL approach itself, 4 h for the visit of a PCB manufacturing and test plant, 3 additional hours to allow the students finishing solving the open-ended problem and working on their final report, and 1 h during which the students evaluated their learning outcome in this particular teaching approach. The course ended with a cake party. The exact course schedule is described in Table 1.

Table 1. PCB testing course organization

Date	Title of the session	Hrs
15/3/4	PBL Go session: collaborative work	2 h
	Individual work at home	
15/4/1	PBL Return session: collaborative work	2 h
15/4/8	OMICRON's visit	4 h
15/5/6	Collaborative work on risk analysis & report	3 h
15/5/25	Student's learning self-evaluation & Cake party	1 h

The beginning of the first session (2 h) was dedicated to the presentation of the PLB approach and the learning objectives to the students: "Go" and "Return" sessions agenda, the students' role inside the group, the problem they had to solve in-group and the learning strategy they had to define. It was crucial that they understood the teacher's expectations about their collaborative and individual learning in order to achieve the course goals. The classroom organization was modified to look like a meeting room facilitating the group discussions. Paper and white boards were also provided.

4.3 Teacher' S Role

In the PBL approach the teacher's role is to guide the students to solve in-group the open-ended problem [1, 3, 4]: he had to diagnose any obstacle (conflict inside the group, misunderstanding of the problem) that would alter each group's progress according to the procedure. He also had to question indirectly the students about their previous know-how of the problem context to orient the discussion and he had to facilitate the exchange of ideas, the negotiations and communication inside the groups.

4.4 Course Progress

Problem Based Learning Approach Presentation to Students. First, the teacher explained to the 12 students (only men) the motivation of the teaching approach choice.

Then, she presented the teaching method it-self: an open-ended problem will be proposed to the students and they will have to solve it in-group, without having any preliminary course. Students will have to identify what they already knew about the topic, what they needed to learn, and how and where to access the information that would lead to the resolution of the problem. It was clearly mentioned to the students that the allocated time to work in-group on the problem in the classroom was limited to 2 sessions (Go and Return ones)of 2 h. So, each group had to identify the 3 or 4 members that will animate both sessions: the leader (who lead the group's discussion during the session), the moderator (who checked the schedule and took care of any logistics aspect), the scribe (who was the instant memory of the group's ideas, concepts and questions) and the secretary (who took notes during the session and sent the minutes back to all group members). The number and the title of these roles can slightly change from one PBL usage to another.

Between the 2 sessions, each student was expected to perform individual work. The teacher concluded presenting the technical and educational objectives. Getting skilled in PCB test concepts and risks analysis methodology and practice were the technical goals. Cooperate actively within the group to the definition of the learning strategy, individually acquire technical knowledge and share it to the group to build collaboratively the competencies allowing the team to solve the initial problem were the educational targets.

Collaborative Work during the "Go Session". During the "Go" session, two groups of 6 students were created based on students' friendship. One group was composed of 5 good classmate students. The 6th member had his friend in the second group, which gathered the remaining students, some of them also being good classmates.

Each group received from the teacher the same note-pad describing the problem to solve, the step by step procedure and the timing to follow to collaboratively understand the problem, identify their prior-knowledge and ignorance to end it having established a learning strategy plan that each student would performed before the "Return session".

The first step of the procedure was to assign a role to at least 4 group members: the leader, the moderator, the scribe and the secretary. The group composed of the good classmates who approved the learning approach, shown a high motivation and quickly performed this task. The second group, composed of only 3 motivated students over 6, met the first signs of internal conflicts at this step as none of the 3 remaining students wanted to take a role. The teacher neither forced the missing assignment nor questioned the reluctant students about their motivation but rather reminded the timing and the objectives of the "Go session" to the group. Facing the fact that their lack of collaboration would penalize the whole group, the unenthusiastic students started cooperating.

In the second step, the students of each group had to read the open-ended problem statement, to highlight the important words and to list the raised questions, the misunderstood or unclear items. The leader had to collect all inputs from the team members, which were written on a white board by the scribe. The moderator had to take care that this task was performed within 10 min.

In the third step, the group had to provide a summarized reformulation of the problem to be sure that the mission was understood and a list of deliverables: to deliver a risk analysis template relative to PCB tests. The secretary had to consign this information. The allocated time was 15 min.

The next step was to make a status of the group members' current knowledge about the topics of PCB manufacturing and test, and risk analysis methodology. It was the first time when the cooperation of each group member presenting his knowledge contributed to build the group knowledge. So, this stage was important because the learning strategy of a group depended of its individual's erudition on the topic. The teacher had to carefully watch the communication inside each group to check that each student gave his statement and opinion. If not, he had to question the leader to make him realizing his mistake. 30 min were allocated to this task.

The 5th step consisted in 15 min to list the learning objectives to solve the problem with the assessment conditions for each goal.

The 6th and last step of the "Go session" was the creation of a Gantt chart describing each task with its duration, allocated resource (documentation) and owner(s), and the list of deliverables to produce. It was important that the students identify the tasks directly linked to the learning objectives, to keep them focused.

The group with the 6 motivated students went through all the 5 steps after the roles assignment without any major problem. The behavior of the 3 unwilling students of the second group, the authority issue that faced the leader and the lack of interaction from the teacher often conduced the group to unorganized discussion, unstructured animation, no teamwork collaboration and a communication restricted to some members. Laboriously, the group followed each procedure step and established a learning strategy plan at the end of the "Go session".

Individual Work. During the 3 weeks separating the "Go" and "Return" sessions, the students had to read the documents provided in the note-pad according to the learning strategy both groups had defined. Each student read all the documentation in order to acquire alone the entire requested knowledge to solve the problem, focused on a particular topic and produced a summary he will share with the group during the "Return session".

Even if it was not requested, each group sent to the teacher a report of the "Go session" which detailed its Gantt chart.

Collaborative Work during the "Return Session". During the "Return session" (2 h) 3 weeks later, both groups discussed their findings and started elaborating together a solution based on what they learned individually.

Once again, they followed a step-by-step procedure. First, each group organized, in 10 min, the assignment of the leader, moderator, scribe and secretary roles. They decided to keep their previous ones even if the teacher suggested them changing.

The second and main step (50 min) was the synthesis of the learning. It required the cooperation of each group member who had to share the outcome of his individual work. Any student who would not have performed his assigned task would impact the technical learning objectives of the group. The individual work was crucial for the group collaborative success. Once again, one group achieved almost straight forwards this synthesis task, whereas the other one faced team conflicts. The passive behaviour of the 3 students influenced a lot team spirit and its outcome as the group ran out of the time allocated to this procedure step.

One again, both groups produced a report of the "Return session".

Visit of OMICRON Company and Outcome. The director spent 3 h presenting the different PCB test steps and equipment to the students. Thanks to the students' involvement in the active learning approach, most of them were able to link the test concepts and technics they learnt to the real usage of the equipment during the demonstrations. All students were happy of the visit and admitted that the experience would not have been so fruitful with a classic lecture teaching method in which they would not have been the protagonists of their learning.

Students' Skills Evaluation. The students had to deliver one risk analysis report per group about the test technics applied to verify PCB based on the knowledge they acquired reading documentation selected by the teacher and the outcomes of the visit.

Students' Learning Self-evaluation. Individually, the students had to evaluate their learning in the context of the PBL approach. They had to complete a dedicated form developed based on an evaluation form from FA2L Louvain teachers [1].

Three main sections composed the document. They were organized as follow:

Student's evaluation of the group performances. Using a spider diagram (see Fig. 2), they had to rank the following criteria:

- Group learning outcome: the group produced something satisfactory, this production was really the result of a collective effort, the meetings were effective, the exchanges allowed bringing to the foreground different points of view to handle the problem.
- Group members' investment and communication: each of the participants contributed significantly to the efficiency of the group, the group gave the opportunity to each of his members to express its point of view even to the passive participants, all the members of the group proposed their individual work done between both sessions.
- Relationship with the teacher: in a general way, the group took advantage of the teacher's presence and guidelines to progress.

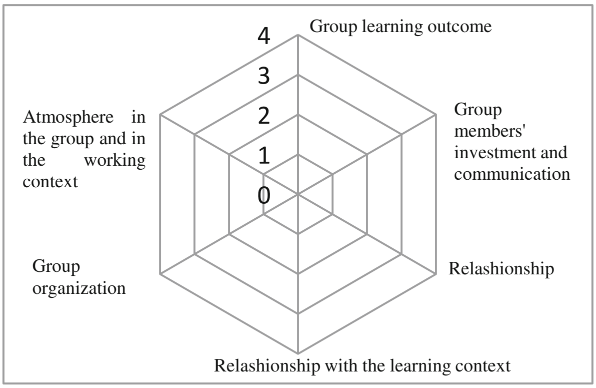

Fig. 2. Spider diagram for the "Problem-Based" approach evaluation by the groups of students

- Relationship with the learning context: the group became quickly motivated to work the theme; the group found that the problem was well adapted to the members that it was enough complex and rich enough for a meaningful learning.
- Group organization: the group succeeded in coordinating its activities, the group remained centred on the task to be carried out, the group made a good use of the white board, the secretary kept tracks of the exchanges, the leader played its role and the timing was respected
- Atmosphere in the group and in the working context: the agreement between the members of the group was good, the participants encouraged each other's, the group managed to surmount its differences of view, and nobody managed to impose his point of view.

The ranking scale was from 1 to 4 with the following meaning: 1 = not satisfying; 2 = not really satisfying; 3 = satisfying; 4 = very satisfying.

Students 'feedback about the advantages and disadvantages of working in-group to learn skills. Each student had to enumerate the actions that went fine in the context of the teamwork, those ones that did not and what he could personally have done to improve the work in-group.

Student self-evaluation of his learning. For this self-evaluation, the students had to fill a table in which they had to list what they learnt and how skilled they were before and after the course. The ranking scale was from 0 to 5 with the meaning explained in Table 2. Students had also to specify the number of hours spent studying individually.

Table 2. Ranking scale meaning

0	1	2	3	4	5
I don't anything about the topic	I have heart about the topic	I can say one or two things about the topic	I can describe the main items of the topic	I can list the relevant items of the topic and the relation between them	I can argue, justify my statement, choices and decisions about the topic

Cake Party. The teacher proposed a cake party to celebrate the end of the course. All students brought food and beverages and shared them as shown on Fig. 3. Students took this opportunity to give a subjective feedback about the educational approach.

Fig. 3. Photograph of the ES students at the cake party

The motivated students were very satisfied as they considered they learnt in a collaborative context close their real work. They liked being the protagonists of their learning and it increased their self-esteem to contribute to the group success. The unenthusiastic students explained they did not like the approach because preferred the classic top-down teaching method rather than this student-centered one.

5 Educational Approach Outcomes

5.1 Analysis of Students' Skill Evaluation

As mentioned earlier, each group produced a summary report of the "Go" and "Return" sessions in addition to the final risks analysis one. Each report was marked. The final mark was the average mark of the 3 reports.

As each member of one group fairly collaborated to solve the initial open-ended problem being all very invested in their own learning as well as in the success of the group, they all obtained the same mark. Concerning the second group, only the 3 motivated students received the highest mark produced by the evaluation of the 3 reports. The 3 others were penalized and lost one point.

This experience shown that evaluating the students' skills using the PBL approach was not an easy task. It was almost not possible to objectively mark the learning a single student acquired during the course. So, when selecting a teaching approach, it is not only important to define the learning objectives but also to identify the "best way" to verify the students have achieved them. The report was an appropriate choice to represent the work produced by each group. But, may be, an additional quiz would have allowed to individually check the students' learning acquisition. As it was the time this course was put in place, there is no reference to compare the students' marks with an estimate the relevance of the teaching approach.

5.2 Analysis of the Students' Learning Self-evaluation

This paragraph presents the synthesis and analysis of the students' answers about three sections of the evaluation form.

Student's Evaluation of the Group Performances. First, the 12 spider diagrams were studied all together and the average values to the 6 items varied between 3 and 3.38, which were high scores as the maximum value is 4. So, as a preliminary conclusion, it appeared that all students recognized the interest of the collaborative work.

As 3 students out of 12 clearly shown a lack of motivation to learn in this collaborative context, a second analysis was performed on the spider diagrams, this time separating the ones from the motivated students to the unwilling ones. The compilation of numbers obviously pointed out a major difference of appreciation of the collaborative teamwork between the motivated and not motivated students. All the compiled numbers are presented in Table 3 and reported on the spider diagram in Fig. 4 using a specific color that code is mentioned in the table.

Table 3. Results compilation

GroupPerformances /# Student	12 students (Blue dots)	9 motivated stud. (Black dots)	3 not motivated stud. (Red dots)
(a) Outcome	3.32	3.53	2.67
(b) Investment	3.17	3.34	2.67
(c) Teacher	3.38	3.17	4
(d) Problem	3.13	3.17	3
(e) Organization	3	3.28	2.34
(f) Atmosphere	3.5	3.8	2.67

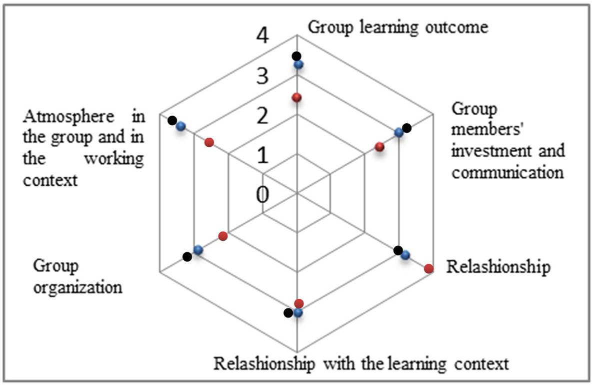

Fig. 4. Graphical representation of the group performances compilation

Students' Feedback About the Advantages and Disadvantages of Working In-group to Learn Skills. The students enumerated the actions that went fine and the ones that did not concerning learning in-group. It appeared that several actions obtained opposite opinions like the assignment of the roles, the atmosphere inside the group, the cooperation of the students, the organization and the distribution of the tasks inside a group that conduced to different workloads between students, the communication inside the group, the animation of the group and the collaboration of each student during the "Return session" to share his outcomes of the whole group.

The students insisted on the fact that the time allocated to perform the procedures during the "Go" and "Return" sessions was too short, in particular to clearly understand the problem and its context. Nevertheless, most of the students were satisfied of the overall process: defining in-group a learning strategy to solve the open-ended problem, studying individually all the documents but focusing on a dedicated topic and sharing their outcome to the whole group to collaboratively allow all members to achieve the learning objectives. All students liked the cake party.

Concerning the actions the students could personally do to improve the work in-group, they mentioned: to be more involve to provide a better collaboration, communicate and helped reaching the learning objectives in less time and in a better team spirit.

Students' Learning Self-evaluation. Even if each student was free to list any relevant learning skill, three main topics appeared from the synthesis of all the lists: knowledge about PCB manufacturing, PCB testing and risk analysis methodology. Each student ranked from 0 to 5 his level of knowledge for each skill before and after the course. The compiled results of all students, of the 9 motivated and 3 unwilling ones are presented in Table 4.

Table 4. Results synthesis

	12 students		9 motivated students		3 not motivated students	
Knowledge /# students	Before	After	Before	After	Before	After
PCB manuf.	1.92	3.1	1.89	2.89	2	3.67
PCB test	1.43	3.4	1.61	3.61	0.89	2.75
Risk analysis	0.75	2.42	0.89	2.11	0.33	3.33

It was surprising to discover, from the analysis of Table 4, that the 3 not motivated students achieved a better level of knowledge on 2 out of 3 skills compared to the 9 motivated students. Were they over-estimating themselves? The number of hours each students had spent learning was studied and it appeared that the 3 students spent an average time of 6.2 h per student studying whereas the 9 motivated ones declared an average of 5.4 h per student. This shown that the 3 students who demonstrated a none collaborative behavior wanted to learn to be skilled in these topics but disagreed on the teaching approach.

The analysis of Table 4 also put on evidence that even if the students improved this initial knowledge on the 3 topics, they were far away to be fully skilled (level 5) at the end of the course.

6 Statement and Improvements

6.1 Statement

Problem-Based Learning approach required a long preparation from the teacher in terms of research on papers, documents, web sites relative to the topics. The teacher has to read all documents to identify the most relevant ones to be proposed to the students in the note-pad.

Despite the fact that the students who studied the documents became skilled on the new topics and able to solve the given problem, the real challenge was to motivate each group members to fairly collaborate and to acquire these competencies. The teacher who became a tutor meaning that her role was to guide the students, had to build their confidence to take on the problem, and to encourage them cooperating in this new learning approach, which represented a paradigm shift from traditional teaching and learning philosophy, which was more often lecture-based. This new tutor role was not easy to play.

6.2 Improvements

Changes have to be applied to this collaborative educational approach to improve the technical and educational outcomes:

- In order to build a real teamwork spirit and to facilitate the collaboration and communication within the group, groups should not be created based on students' friendship.
- The teacher has to interact more often, in particular when diagnosing any conflict between group members and normalize it, or when the group shows a lack of dynamism du to none fairly collaboration of each member in order to minimize the impacts on the group success.
- The teacher should add regular milestones to check students' knowledge progresses.
- A solution has to be found to allow students practicing and acquiring know-how on these technical topics.
- The teacher has to spend more time explaining the different roles and has to ask the leader and the moderator to respect the timing. May be a game that rules would fit to the PBL ones could be a good way to initiate the students to the new collaborative approach.
- The teacher has to identify the appropriated exam mode to verify each student achieved the technical learning objectives.

7 Conclusion

From pedagogical point of view, the "problem-based learning" approach was an interesting experience for the 5th year apprentice engineer students as they discovered an innovative learning method where they were the protagonists of their own learning and which allowed them to study in conditions close to real world work when collaboration is in purpose. For the students, the gains of this approach were the acquisition of technical knowledge in PCB test and risks analysis methods and they got trained in thinking strategies, decision-making, negotiation and collaborative work.

For the teacher, this approach requested a long preparation, as it was necessary to develop dedicated course syllabus as well as course material to fit the PBL approach procedure and the learning objectives. The teacher had to get familiar with his new role of instructor or tutor, which was not a natural thing. He had to facilitate learning by supporting, guiding, and monitoring the learning process of the students in-group without ordering them.

Based on this first positive experience, the PBL approach will be repeated in 2015–2016 taking into account all the enumerated improvements.

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Fostering Math Competencies Through Online Collaborative Editing Tools

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Abstract. In introductory math courses, especially Calculus 1, dropout rates and failure are generally high, and creating activities that increase retention and motivate students to obtain better final results is a challenge. In order to develop several competencies in our students of Software Engineering courses, Calculus I at Universidad ORT Uruguay focuses on several competencies such as: synthesis, abstraction and problem solving (based on the ACM/IEEE Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering). Every semester we reflect on our practice and try to answer the following research question: What kind of activities can we design in Calculus 1 to retain students and obtain better results? This paper explores students' perspectives on creating an article based on IEEE conference format related to one of the course topics and present the work in class using a poster. Preliminary results show an increase in retention and significant differences in final course results compared with two control groups. Collaborative learning activities using online editing tools encourage students to become self-learners and our role as teacher changed from being the center of the class to becoming a moderator where the principal figures are the students.

1 Introduction

In introductory math courses, especially Calculus 1, dropout rates and failure are generally high, and creating activities that increase retention and motivate students to obtain better final results is a challenge. Calculus is the entry point of most undergraduate Engineering Science courses and often is a prerequisite for Computing Curricula courses [1].

Mathematics is an important foundation for many science and engineering disciplines [2] and developing mathematical competencies represents the single largest investment by educational systems worldwide [3]. Attrition rates for engineering undergraduates remain high and most universities are motivated to understand the key factors contributing to low retention of engineering undergraduates [4].

Engaging future engineers is a central topic in engineering education and it is imperative that the community adopts strategies and tools for using a multiple perspectives approach to better understand engineering education [5].

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Traditional lecture style of teaching has long been the norm in college science, technology, engineering and mathematics courses, but innovative teaching models are gaining popularity [6]. Felder argues that collaborative and student-centered learning is superior to passive teacher-centered approach. Specifically with this approach students acquire knowledge through practice and reflection rather than watching and listening to teachers telling them how to do the task [7].

Collaborative learning is a key component of software engineering courses in most undergraduate computing curricula [8]. Thus, collaboration is efficient at promoting students' learning outcomes, academic achievement, attitudes and retention.

Engineering faculty must promote student collaboration in their courses [9]. Primarily because most engineering is done collaboratively, so future engineers will have to work in teams in their professional careers [10]. Collaborative and cooperative learning prepare students to solve problems by showing them the benefits of group work and initiating them into real world problems [11]. This approach requires students to take responsibility for their learning and organize their time effectively both in online activities and in class sessions [12].

Several collaborative learning approaches are emerging with this new road of learning by doing tasks, incorporating concepts as flipped-classroom, peer instruction, just-in-time teaching, online learning platforms, MOOCs, etc. but there is still no magical solution to these problems mentioned before.

In this context, every semester we reflect on our practice and the main research question to answer is: What kind of activities can we design in Calculus 1 to retain students and obtain better results?

2 Course Context

Universidad ORT Uruguay is currently the largest non-governmental University in the country. Historically committed to offering quality education, Universidad ORT Uruguay has been engaged in research and development activities in the field of education for over 20 years [13].

Every semester 120 freshmen take Calculus 1 as a compulsory course. Small groups of students allow us to design student-centered activities that benefit our students with the opportunity to learn topics in a dynamic class environment using student-centered pedagogies and active-collaborative learning strategies.

Freshmen students take this course every semester. With a maximum of 30 students, student-centered approach provides an ideal learning environment. These conditions allow and encourage retention. As mentioned by Tinto [14], one of the most important aspects that promote the retention is an environment that fosters learning. Learning is the key to student retention and students are more likely to persist and graduate in a context that provides academic, social and personal support.

3 Activity Proposed

We considered the activity of creating an article based on IEEE conference format [15] related to one of the course topics (Taylor Series, Sequences and Series, Complex Numbers and Integrals) using online collaborative editing tools and asked students to present the work in class using a poster.

First, we designed the experiment in order to differentiate collaborative activities online from traditional take-home work. One random group of freshmen was selected to participate in the experiment. Common syllabus, notes, assignments and teachers' experience were used in control and experimental groups. The experimental group had to develop additional collaborative activities such as creating a paper online in Overleaf [16], use GeoGebraTube [17] as an online repository of activities and present results in class.

Control groups performed only the poster activity without the requirement to present it in class or compare topics results using different mathematical tools. Students of the experimental group had to develop one of the topics of the course and compare results using different technological tools widely used in mathematic education such as WolframAlpha [18], Maxima [19] and Geogebra [20].

As a requirement of the task students were asked to do it in LaTeX (typesetting programming language used for technical or scientific documents) using Overleaf (LaTeX online collaborative editing tool) [15]. Overleaf [16] is being used to teach mathematics and other disciplines providing students with templates assignments in LaTeX online. Each student can compare different versions of projects and their changes; meanwhile, the teacher can see the advance of the project and review assignments to give them early feedback.

Finally, students were divided into groups consisting of two members assigned to one project. Each group selected one specific topic in order to cover all the course topics. Students developed the work in two stages: first creating the paper of the selected topic and then exhibiting the work in class with a poster at the end of the course.

It should be noted that the pedagogical approach of this proposal is based on social constructivism where learning is a process by which students are integrated into a knowledge community [21]. Also, as a constructivist method students construct their own versions of concepts rather than simply absorbing versions presented by their teachers [22].

4 Discussion

The format presentation regarding the topic was not the only important aspect. The high level of reflection and analysis of the various tools from the perspective of students was surprising. In turn, the complexity of the subject allowed students to undertake encodings in LaTeX related to the different functions presented in the course.

This collaborative work allowed students to work collaboratively using Overleaf [16] and creating online activities proposed by themselves in GeoGebraTube [17]. Students use collaborative tools in a natural way and with much enthusiasm.

Excellent posters were done by both control and experimental groups. In this item, the control group also presented results in class as an informal poster section.

The high quality of papers done by students and the high degree of motivation and engagement corroborates that meaningful learning occurs when students assimilate new information into the existing knowledge or when they alter understanding to accommodate new knowledge [22]. Activities that require students to collaborate, share solutions, review each others' work, or create materials have shown to be beneficial for the students [23].

In summary, several major challenges were presented to the students:

– Produce a collaborative paper of a new topic in a new programming language (LaTeX).
– Create a poster abstracting the paper content.
– Set their own learning goals in the selected topic.
– Present the poster in class fostering their communication skills, reflection and critical thinking.
– Be independent learners.

According to qualitative feedback, students commented as a positive aspect the challenge of this proposal. Almost all students remarked as a negative issue the time spent writing the article and making the poster. Nevertheless, while some expressed as negative the difficulty of dealing with a new language others remarked the task as positive. Finally, almost all students expressed the pleasure of this methodology.

Finally, it is important to notice that reflections vary from memorizing, describing and explaining to relating, applying and theorizing. In carrying out this proposal we observed that almost all of the results of the tasks showed high levels of student engagement.

Unsurprisingly, these findings and discussion indicate that this type of activity encourages students to become independent learners. In this context, our role as a teacher with this approach of learning-by-doing changed from being the center of the class to becoming a moderator where the principal figures are the students.

5 Conclusion

Academic performance in mathematics is not achieved all at once or with a single activity. It is important as a teacher to reflect on our own practice, including a variety and innovative proposals with the objective of engaging students, increasing retention and obtaining better results. Almost all students of the experimental group expressed pleasure with this methodology.

It should be noted that collaborative learning using online editing tools has innumerable advantages and promotes several competencies both specific (abstraction, synthesis, problem solving) and transversal (teamwork, communication).

The high degree of motivation and engagement of our students exceeded our initial expectations, showing that it is possible to continue in this direction. This year, we plan to experiment with more groups trying to validate preliminary results.

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Developing Electrical Engineering Course in an Active Cooperative Learning (ACL) Platform

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Abstract. The Department of Electrical Engineering plans to run one of its basic courses, Introduction to Electrical Systems and Computation (EE 206), in Active Collaborative Learning (ACL) format. We have surveyed and examined several alternatives and flavors of running ACL, in an attempt to customize a platform that best achieves the course objectives. Issues related to team formation, team management and team assessment were debated. A survey of similar courses in other leading universities was conducted. The authors had the opportunity to test parts of the proposal in their running courses during the phase of the new course development. The feedback and lessons learned were incorporated to make adjustment and fine tuning to the proposal. The course is divided into four modules: Introducing EE fields, Project I: Research Activity, Matlab, and Project II: Robotics. In drafting the pilot course material, we did every effort to provide the fine details so that instructors feel comfortable with the approach. A complete set of documents has been developed to run the course in a productive and engaging manner.

Keywords: Active learning · KFUPM · Electrical engineering

1 Introduction

The widespread and growing adoption of active Collaborative learning (ACL) techniques is changing education. The Accreditation Board for Engineering and Technology (ABET) is requiring higher education institutions to introduce teamwork activities into their curricula. Collaborative learning, cooperative learning and other forms of active learning are being used in classrooms as ways to promote teamwork among students and enhance their learning.

The Department of Electrical Engineering (EE) has decided to run one of its basic courses, Introduction to Electrical Systems and Computation (EE 206), in ACL format as a pilot for other courses in the future. According to the department bulletin, the course catalog covers:

Introduction to fundamentals of EE: circuits, energy, communication, control, signal processing, electromagnetics, electronics, and digital systems. Computational

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techniques. Instrumentation and measurement. Introduction to technology and applications.

This course was adopted for the pilot study for four reasons:

1. It is a core course; all students in EE will be exposed to the experience.
2. It is a sophomore course; the experience is provided to students early in their program.
3. The course bulletin description is flexible, which provides high level of freedom for the designers.
4. It has a set of skill-oriented objectives, which can best be achieved by ACL.

We have surveyed and examined several alternatives and flavors of running ACL, in an attempt to customize a platform that best achieves KFUPM goals at large and the course objectives in specific. After that, a complete set of documents has been developed to run the course in a productive, engaging and entertaining manner. Every effort has been made to provide detailed guidance for both students and instructors of the course in all aspects (preparation, delivery, management, assessment).

The material in this paper is organized in three sections. The first section summarizes the experience learned about ACL in the literature as well as from the researchers' own experience. The next section surveys similar courses offered at some international universities. The third section focuses on the course design including course syllabus, breakdown, management and assessment.

2 Active Collaborative Learning

Working in teams is unquestionably the most effective form of collaboration. Organizations recognize that new employees need to bring team work skills to the workplace. Although employers may be willing to provide on the job training, they expect that their new employees possess an acceptable level of this skill to start with. For this reason accreditation boards at the collegiate level such as the Accreditation Board for Engineering and Technology (ABET), the Accounting Education Change Commission (AECC), and the Joint Commission for Accreditation of Health Care Organizations (JCAHO), among others, are requiring higher education institutions to introduce teamwork activities into their curricula [1].

A widely accepted definition of a team is given by Katzenbach and Smith [2]: "a small group of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable". Not all groups are cooperative. In a truly cooperative group, members promote each other's success through helping, sharing, assisting, explaining, and encouraging. They provide both academic and personal support based on a commitment to and caring about each other [3].

The majority of the existing literature on teams comes from instructors' experiences and experiments. The most relevant papers, from which some of the ideas in this report have been learned, can be found in [4–8]. The site www.foundationcoalition.org [9] has a rich collection on various issues of teamwork.

2.1 Team Formation

When it comes to forming teams, the main issues of concern are team size and criteria for grouping. There is no consensus in the literature on the optimal team size. Small teams lack diversity of opinions and have tendency to be unstable due to dropouts and absences, while larger teams are difficult to meet, manage and reach agreements. Chances of "free riders" are higher in larger groups as well. Another parameter that could influence team size is the maturity of students with regard to team work. For students who have previous experience to work in teams, large teams are still manageable. For first time team workers, a smaller team is safer [10]. A number between three and five is reasonable for most cases.

Forming the groups should not be left to students, but should not be a complex process on the other hand. When students are left to form their groups, the common criterion would be 'friendship". While this approach ensures harmony of the team, especially at the start, it may not be the most effective way to carry out the team work.

When the instructor forms the groups, he should look for a good mix of academic standings (above average, average, blow average) within each team. Literature shows that this approach is beneficial to the group and to all individuals. Weak students learn from good students and good student teach weak students, making the environment truly cooperative. The benefits to good students from tutoring are by no means less than the benefits to the weak students from being tutored. It is well proven that when we teach others we master the knowledge we have. It should not be concluded, though, that the contribution to teams comes all from high GPA students.

How would academic standing be assessed? The direct measure is probably the student cumulative GPA. However, some students may be reluctant to share this information with others, even with the instructor. Weak students, in particular, may be concerned about their image in the eyes of the instructor. An alternative that is equally sufficient for assessing the academic standing is the student grade in the pre-requisites and other related courses. Student will be less conservative to mention their letter grade in few courses. This information may still be optional. Students who choose not to provide this information can be distributed over the groups, keeping in mind that it is highly probable that they are average or below average students.

If the groups are formed late in the course (say after one third of the semester has passed), the instructor can rely for academic standing on his perception and on students' performance so far (quizzes, participation …).

Another criterion worth considering in team formation is skills and past experience relevant to the project tasks, for example: hands-on work, manufacturing, programming, project management, etc. Students who possess such skills and experiences should be treated as class common resources, and should be evenly distributed and not clustered in one team.

Many references consider some societal-related attributes in forming the groups, e.g. gender, minorities, home/oversees, nativity, hobbies. These factors are not universal and are very much culture-dependent. The bottom line is that factors that can foster or jeopardize the harmony of the team should be considered.

If the team is expected to have several meetings outside the class, it is plausible to consider the convenience of holding such meeting by the team members.

Many references have suggested designing a form to collect the information that assist in forming the teams. Some forms are simple, and some are quite involved, using Myers-Briggs Type Indicator (MBTI), Herman scale or social style index [11, 12]. Some references have gone as far as building an automated algorithm for sorting the group [13].

2.2 Team Management

A popular model of the phases developed during team work is given by Tuckman [14]. His model specifies four stages of team development: *Forming*, *Storming*, *Norming* and *Performing*. Details about the features of each stage can be found in [15]. The main conclusion is: it takes some time before the team starts performing.

If time allows, a session of icebreaking will be useful and entertaining at the same time. The activities for icebreaking are very open. Plenty of ideas are collected in [16]. Look for activities that make the team know each other well, in terms of personality and capabilities. Activities which create competition between teams will indirectly strengthen the inter-team bonds. Activities related to the nature of the team tasks will be favorable, but not necessary.

Nothing puts the team on the track of performing better than clear objectives and instructions. The assignment for the team has to be very well-defined, and deliverables have to be spelled out. The team members may also be encouraged to draft their own internal contract or code of cooperation for carrying out the job, resolving conflicts, sharing responsibility and so on.

An issue of major concern in the performance of the teams is to share the work as evenly as possible. In the education environment, the objective of the teamwork should not be limited to the final product, but should, more importantly, ensure that every member has learned through the process. In the authors' views, it is not sufficient to account for individual assessment in the final grade, but there should be an implicit procedure to ensure that every member has played a significant role in the team. The Jigsaw technique (to be explained in the following section) stands as a shiny model of enforcing shared responsibility.

A typical approach would be to assign a role for each team member, including leadership, and rotate them over the span of the work. Another approach is to divide the tasks into subtasks, and assign each subtask to one or more members. If this approach is adopted, one has to be cautioned not to turn the whole project into isolated subtasks. Students must, at times, get together, discuss their work and integrate it well. The bottom line is that the instructor has to design for participation throughout the project, and not be content with "individual" and "group" assessment on the last day.

2.3 Team Assessment

This issue has always been the main challenge in teamwork. How can we translate group activities into gradable items with clear rubrics? How to strike a balance between individual and team evaluation? Can we identify and minimize free-riding?

Grading team work is not as straightforward as grading individual work. Usually a team is charged with a task that will only be completed in a final product. But it is not advisable that the grade depends on the final product only. It is important to identify phases, milestones or sub-tasks and assign them partial credit. This approach has three advantages: it provides early feedback to students, motivates them throughout the project, and reduces the risk of a poor final grade.

The purpose of grading the activities before the final product is somehow different from usual grading objectives; it should focus on doing the job seriously and on-time rather than penalizing for mistakes. Students will have the chance to fix their mistakes, so they should not be penalized for doing something wrong on the way, because it is part of the learning process. This approach will also encourage them to take risks and be innovative.

Nonetheless, the grading policy has to be made crystal clear to students. The items for partial grades should be spelled out, and the deliverables of each task should be identified without ambiguity.

When students work in teams, it is a fact that they will not only learn from each other, but some will benefit from others in terms of grade. This is normal, and should not be annoying to instructors. Nonetheless, we have to make some distinction between the individuals. When students work in a team, their individualism appears in three aspects:

(1) Ability: both academic-wise and skill-wise.
(2) Commitment: how serious and responsible an individual is in the group
(3) Comprehension: how much he learned from the group exercise at the end.

The authors are of the opinion that individual assessment should be directed to (2) and (3). We should not try to devise a tool to assess the fine distinctions and variations in student contribution to the group because of their varying abilities and skills. This will defeat the purpose of working in teams, and reflect negatively on the attitude of both good and poor students. We know that students have different academic abilities, and we deliberately formed a mix of levels to let students help each other.

How should the total project grade be distributed between team and individual work? There is not specific formula, but it should be such that the team portion is large enough to keep strong motivation for teamwork, and the individual portion is significant enough to make fair distinction in the final grade. Team/individual distributions in the range 30/70 up to 60/40 are advisable.

Some authors have reported their experience of weighing the final grade of each individual by a factor related to their position relative to the group average. We believe that this scheme should be applied with extreme caution, as it may end up boasting the grades of the high achievers in the team because they have, to their luck, weak members in their team!

The problem of free riders is of major concern to instructors as well as hard-working students. In fact, it could be one of the main factors behind discouraging instructors from adopting team-based learning in their courses. The strategy towards free riders should be of threefold (1) to identify them early in the wok, (2) to monitor their behavior throughout the project and send them clear signal to change their attitude, and (3) to penalize them severely if they stay careless. The strategy calls for changing their behavior and not only judging them at the end of the project.

We have to admit that students, in general, do not feel comfortable to evaluate each other, especially if this evaluation is going to be part of their grade in the course. Yet, peer assessment, or “auto-rating” as some authors like to call it, is one of the important practices in teamwork and we must take the members into it gradually and in a guided manner.

Team members should be informed in clear terms that they are rating the commitment of their colleagues, not the academic ability, or personal skills. To make their job easier, they may be given certain attributes for evaluation, along with detailed rubric, for example

1. Punctuality:
   Does your colleague attend group meetings both inside and outside class?
   (a) Attends all meetings & come on time
   (b) Attends most of the meetings & mostly on time
   (c) Attends only few meetings and often shows up late
2. Participation:
   Does he participate in group discussion?
   (a) Proactive, initiate discussion and raise concerns
   (b) Does not actively participate but responds to raised queries
   (c) Does not show any concern
3. Commitment:
   Does he deliver his assigned task well done and on time?
   (a) Delivers well done and on time
   (b) Delivers incomplete or/and late
   (c) Does not deliver

Note that none of the attributes are directly related to academic ability.

3 “Introduction to EE” in Reputable Universities

In order to design a successful “Introduction to EE” course in ACL framework, a survey of similar courses in other leading universities is sought. We look to learn more about the objectives, content, method of delivery and the type of projects in which such courses are offered. The list includes MIT, Purdue, Georgia Tech, Carnegie Mellon, Cornell, University of Southern California, University of Illinois, UT Austin, and others. The lessons Learned from the survey may be summarized in the following points:

Following are the main observations deduced from the above surveyed schools:

1. The content of the offered courses include one or more of the following: overview of different areas of electrical engineering, highlighting general engineering concepts, and explaining electrical devices.
2. Most courses focuses on infusing various skills in addition to content.
3. Some courses emphasize engineering design.

4. Most courses have a hands-on or experimental part in the form of lab work or project
5. Many of the surveyed courses use robots for their experimental work. This tool allows to incorporate concepts from a broad range of areas within EE.

4 Course Design

The course EE 206 is of two credit hours, offered at the early sophomore class. The course objectives are:

(1) Emphasize the role of engineering in society
(2) Introduce the various disciplines of electrical engineering
(3) Motivate students towards the profession
(4) Demonstrate basic concept in the context of some widely encountered electrical engineering systems and devices
(5) Introduce skills that are important to industry
(6) Getting hands-on experience with MATLAB.

The course is designed to have four modules. The first module introduces the students to the different disciplines in Electrical Engineering. It spans 3 weeks. The second module is a team research activity (Project I), and it lasts for 4.5 weeks. The third module spans 4.5 weeks and it is another team activity using Robotics (Project II). The fourth module introduces the students to MATLAB®, and extends for three weeks. Therefore, 60% of the course is spent in team work.

4.1 Introducing the Different EE Fields: Energy, Control, Electronics,…

This module of the course is mainly lecture-based and is meant to introduce the student to the different subfields under electrical engineering. This helps the student to comprehend the scope of electrical engineering. The subfields cover Communication, Electromagnetic, Signal Processing, Power, Control, Electronics and Instrumentation.

The following topics are introduced under each subfield in brief:

Communications: Types of channels, transducers, frequency spectrum, modulation and multiplexing.
Signal Processing: Applications to Communications, Medicine, Seismology, Image Compression.
Electromagnetics: EM spectrum, Antennas, Optics.
Power: Power Grid, Power system Components, Electricity Market Model, Renewable Energy.
Control: Servo-process, Servo-devices, Modeling of Physical Systems, Controllers.
Electronics: Semiconductors, Diodes, Transistors, Op-Amps, VLSI.
Instrumentations: Sensors, Actuators, Open loop, Closed Loop.

The lectures are mainly descriptive, with little or no equations. Emphasis is on the main simple concepts, terminology and common applications which students see and feel around. A set of reading material is provided as supplement document.

This module is concluded by a short MCQ test, which carries 20% of the course mark.

4.2 Project I: Team Research

In this module students will be working in teams to do a simple research. This module aims to develop students' abilities in the following:

- Learn independently.
- Work effectively in teams.
- Communicate technical information in both written and oral form.
- Plan and execute short term projects.
- Teach others.
- Assess peers professionally and objectively.

Each team should study an electric device of their choice. The team should address fundamental details of the device. For example, they should attempt to:

- Describe the device and its components.
- Explain how it works.
- Trace its development over time.
- Identify the main challenges in its fabrication/operation.
- Compare it to other relevant devices, emphasizing pros and cons.
- Foresee the future of the device.
- If possible, demonstrate the device or part of it, in the form of experiment, computer animation, physical examination, computer simulation etc.

The project will run in "Jigsaw" format, where:

- Students will be grouped into a number of "Study" Groups (SG), based on the class size.
- Each SG, in consultation with their instructor, will choose a device to study.
- Each SG has to come up with work plan and submit regular progress reports.
- Each SG will meet with their instructor to discuss and clarify any lacking concepts related to their study project.
- The SG will finally come up with a "Poster" describing their project work.
- Students will then re-assemble in Teaching Groups (TG), where every TG will have one member from each SG.
- Each student in the TG will be assigned a time slot to teach his group and explain to them the device he studied. He should be ready to receive their questions.
- Every student should submit 4 multiple choice questions related to the device he studied.

This module is assessed according to the following scheme:

- 65 points for Individual work (5 pt Individual Proposal, 10 pt Peer evaluation by SG group members, 10 pt Peer evaluation of presenter by TG group members, 10 pt Instructor evaluation of student throughout the project and in presentation, 10 pt Question setting, 20 pt Test (Collected from student MCQ's).
- 35 points for Group work (5 pt Group Proposal, 10 pt Progress sheets, 20 pt Poster content and quality).

This module carries 30% of course mark.

4.3 Robotics

Based on the review we have conducted across many universities, robots are being used to introduce many engineering concepts. This module aims at achieving the following objectives:

1. Demonstrate the multidisciplinary nature of real life systems and problems.
2. Highlight the engineering approach for problem analysis and solution
3. Enhance students' ability for self-learning.
4. Work effectively in teams.
5. Plan and execute short term projects.

The robotics module, which spans 4.5 weeks, is made up of 4 mini-projects and a competition. Each mini-project spans one week, and the fifth week is dedicated for the competition. All mini-projects are setup in a way to foster team-working skills. Engineering thinking is impeded in the project execution. This includes debugging, finding and evaluating alternatives, …etc. The specific learning outcomes of each mini-project are specified.

The last week of the robotics module is dedicated for the competition. Each team designs a robot to implement a given challenge, for example a maze solver or robotic sumo wrestling. The level of difficulty can be controlled by the rules and conditions. The students are encouraged to think in a creative way and have a feeling of competitiveness, thus the team spirit is further strengthen. The evaluation in the competition is based on the design efficiency, completeness of task, level of involved concepts. The competition takes place in a public domain and faculty are encouraged to attend.

The total mark of earned points for this module constitutes 30% of the course mark.

4.4 Programing with Matlab

The objective of the programing module is to introduce EE student to different EE software packages, with emphasize on Matlab. Students are introduced to the interface environment, language syntax, basic linear algebra operation, plotting commands with basic application to signal processing.

Students are examined in this module through MCQ test at the individual level. It weighs 20% of the course total mark.

5 Conclusion

KFUPM made its strategic move to active learning. The increasing interest in active cooperative learning should be addressed gradually. Students as well as faculty should be trained to work in this environment.

The process should start early at the course objective level. The course objectives should clearly indicate the desire to infuse soft skills and teamwork as part of the learning process.

In this project we proposed a pilot program for implementing ACL at one of the core courses at Electrical Engineering Department. We reviewed the accumulating experience of instructors' in team-based learning, and customized it to the system at KFUPM. We also surveyed similar courses at reputable universities. In drafting the pilot course material, we did every effort to provide the fine details so that instructors feel comfortable with the approach.

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Faculty Perceptions on Publishing Research

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Abstract. Today's researchers have not only the traditional publications, but the open access publishing method whereby research papers can be published via the Internet as well as print publications. Researchers must carefully scrutinize the open access publishers in order to ensure the publication is a legitimate scholarly publication.

Keywords: Predatory publications · Open access publications · Peripheral publishing · Paid publishing · Hijacked publications

1 Introduction

The pressure in academia to publish has long been an accepted standard regarding faculty employment, tenure, and promotion. Educational institutions are being pressured to increase and/or retain enrollment amid global competition, and they are touting published faculty as a competitive advantage in attracting students [17]. The reality of "publish or perish" means that new journals can easily locate authors who are willing to publish in them [29]. According to Dudley [24], academia's expectations for high-yielding research as well as the multitude of new researchers entering the landscape are factors contributing to the rise of "predatory publishers," or ill-reputed organizations that charge authors high publishing fees to publish their research. Dudley believes the culture is in need of repair, but until that sea change occurs, researchers must thoroughly investigate the legitimacy of publications to ensure their research is being published in a reputable source.

The researchers for this qualitative study will explore publication-related issues in the for-profit higher education arena. The study includes six sections: (a) a detailed literature review, (b) research methodology and a summary of data, (c) future research, (d) strengths and weaknesses, (e) limitations, and (f) concluding comments. The literature review includes an evaluation of the areas of change in the publication world, open access publications, and predatory publications.

2 Literature Review

2.1 The Changing Face of Scholarly Component

Only 15 or 20 years ago, the choices for scholarly publication were much more limited. Today, choosing from the range of options such as open access journals, online-only

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journals, self-publishing options such as institutional repositories, and even social media channels can be overwhelming for busy researchers. Many factors can determine where scholars choose to publish, such as their intrinsic trust in an outlet or how much a particular type of publication will count toward tenure and promotion decisions. These factors can vary by institutional or regional expectations. There are differences among scholars in more developed and less developed countries [33]. Based on their research, faculty in more highly developed countries are less concerned about which journals they cite in their papers and are more concerned about publishing in peer-reviewed publications than their counterparts in less developed countries. Additionally, they are less comfortable with publishing in institutional repositories or on social media.

Richardson and Parker [50] studied the "relationship between various types of research or scholarly activity and evaluations of teaching" (p. 79). Because a typical professor's evaluation is based on three key elements of service, teaching, and research, oftentimes in colleges and universities, tenured professors are rarely in the classroom due to their research obligations [27]. At not-for-profit institutions of higher education, the emphasis is on the student in the classroom providing timely feedback and engaging the student as best they can in the electronic environment. Richardson and Parker presented the idea that teaching-oriented institutions/faculty that pursue research often divert their attention from the students and teaching (Fig. 1). Conversely, research-oriented institutions/faculty who conduct to supplement and support their teaching could improve the faculty members' engagement in the e-classroom (e-connectivity) [53] and could achieve higher faculty evaluations (Fig. 1).

Teaching-oriented institutions > research interferes > teaching

Research-oriented institutions > research supplements > teaching

Fig. 1. Comparison of teaching-oriented versus research-oriented institutions

2.2 Maintaining the Integrity of the Specifications

Today's students commonly publish their theses and dissertations electronically, whether through ProQuest or through their university library. Electronic theses and dissertations (ETD) are generally considered to be freely available to the world. Questions exist regarding whether ETDs have been officially published: if the source document is freely available, are students able to publish the work in journals? It can depend on the discipline. Research originally published in ETDs and revised for publication is welcomed by over 80% of journal editors in the social sciences and humanities, and by about half of scientific journal editors [47, 48].

The increase in publication options, as well as the ever-growing increase in the cost of purchasing access to peer-reviewed serials published by big companies such as Elsevier and Springer, has led to the rise of open access (OA) journals. OA is dramatically changing the long-standing precepts of scholarly communication. "The goal of the OA movement is to make scholarly literature freely available in digital form worldwide with minimal restrictions in their use" [31]. In traditional journal publishing, faculty members submit their work to a journal that is published by a commercial publishing house for peer review and publication. University library budgets cover the cost of purchasing access to the journals from the publishers. In OA, publication is sometimes free to the authors, and sometimes they must pay. A discussion of OA models and uptake concerns is now warranted.

3 Open Access Publishing

As previously stated, OA came into existence partly because the price of journals and other publications for institutions has become prohibitively high [20]. OA has made volumes of published works free via the Internet [8]. A tenet of OA is that the reader does not have to pay to access the work [19]. The shift from what could be called the "reader pays" model to the "author pays" model signifies a shift in administrative responsibilities on the publisher's end as well.

Three periods exist for OA publishing, the pioneer years, the innovation years and the consolidation years [40 as cited in 6]. OA publications include four different models, the traditional, gold, green, and platinum [6]. The gold model is very common; in this approach, authors pay a publication fee to the journal [29]. Typically, the authors pay the publication fee, which varies among journals, with grant funds. In some other models, the author's university library pays the fees, which creates complex problems for libraries [37]. Not all OA journals charge for publication; some of these journals are edited by volunteers. In fact, only about a quarter of the journals listed in the Directory of Open Access Journals charge for publication [39].

Understanding scholars' responses to and knowledge about OA are essential, because if they do not choose to submit their work to OA publications, the model will fail. The switch to OA publishing will not happen quickly because faculty are more incentivized to publish in traditional, well-known journals for tenure and promotion purposes [54]. No relationship exists between OA status and the influence of a journal's citations, and that while the question of who pays for publication is still in question, publication paid author fees to publish, and almost 70% had never self-archived a paper [19]. OA publication increases citation counts for legal scholars [22].

Concerns surrounding OA certainly exist. Copyright and time are faculty members' most prevalent barriers to adopting OA [36]. Engineering faculty members are reluctant to participate in Gold OA publishing due to its cost; additionally, they have other publication options that are considered equally important, such as conference proceedings and technical reports [42]. Commercial publishers and OA models have not co-existed well. For example, Elsevier notified researchers the PDF versions of their published articles were being removed from www.academia.edu, which is an influential website for academics to share their publications with their peers. Although researchers were provided other means of sharing their published works in an Elsevier publication [25], it is questionable whether researchers will continue to submit their papers for publication to OA journals or self-publish them in institutional repositories in light of the difficulties. The quality of OA journals is occasionally questioned. For example, Beall anecdotally observed a decline in the quality of the highly respected and peer-reviewed journal *Information Technology and Libraries*, a publication of the American Library Association's Library and Information Technology Association, after it transitioned to OA [4]. Perhaps the most serious concern about OA is the existence of OA publishers who are considered "predatory" [4]. Predatory publishing will be considered in the next section.

4 Predatory Publishing

"Scholarly published literacy" (p. 3) scams are found more in gold open access than any of the other models since it is author paid [5]. Generally, after the author pays to be published, the publisher's follow-up is very weak. The publisher is under the impression that the authors want the fastest way to get their work out to the reader so the publisher will cut corners to accomplish that goal. For example, all works are not peer reviewed when the publishers state they would be, and they call for more articles than they can handle in order to make as much money as possible [3, 4]. Authors fall prey to these scam artists because they need to publish their work so badly. While it is easy for new researchers to fall victim to predatory publishers [14, 41] in their eagerness to publish, conducting due diligence and careful study can help navigate the perilous waters of open-access publishing. It is up to the author to find quality publishers, although they may not know how to determine whether a publisher is reputable. The problem is beginning to be treated with some urgency: "Fake publishers and impact factors reminded us of the urgent need to evaluate the methods that currently are used to assess academic research" (p. 394) [32].

The predatory problem is of particular concern in medicine and the sciences. Researchers in these fields are the most common users of the gold OA model, since their funding sources tend to be quite large and they are the most able to pay author fees [15]. High-impact scientific journals such as Nature and Science have demonstrations of the gravity of the situation. For example, on a computer-generated article that was accepted for publication in The Open Information Science Journal; the journal's editor resigned after stating he did not know the article had been accepted [28]. Bohannon sent a spoof paper to OA journals lacking peer review, with telling results:

> Ocorrafoo Cobange does not exist, nor does the Wassee Institute of Medicine. Over the past 10 months, I have submitted 304 versions of the wonder drug paper to open-access journals. More than half of the journals accepted the paper, failing to notice its fatal flaws. Beyond that headline result, the data from this sting operation reveal the contours of an emerging Wild West in academic publishing (p. 60) [13].

Butler described a journal identity theft situation in which counterfeiters had used the names of the respected journals Archives des Sciences and Wulfenia to create author-pays journals [16]. "The scammers attend to the closest of details, displaying on multiple websites not only the titles of the authentic journals, but also their impact factors, postal addresses and international standard serial numbers — the unique codes used to identify journals" (p. 421). The counterfeit journals instructed authors to send their fee, $500 per article, to Armenia.

A conflict of interest for publishers exists, because the more papers the publisher accepts and the authors pay publishing fees, the more money the publisher earns [6, 8]. Predatory publishing might also have a negative effect on the body of research in general [45]. Since research is cumulative, researchers cite the works of other researchers. If research papers are published by predatory publishers and the work is not grounded in scientific theory, all other works of research citing such an article will be placed in doubt. Open-access publishing has allowed researchers the ability to publish through a wide variety of digital publications. The "research-driven model" (p. 8) should be a continuing conversation among academics and researchers to ensure the quality of the research is not compromised [24]. Despite the potential negative impact from open-access publishing, OA serves a benefit to scholarly communities because it allows a broader set of researchers to contribute their work to the body of knowledge [20, 45].

Institutions are the biggest culprit when it comes to predatory publishing. Most institution requires that faculty publish in order to move on the pay scale or to be promoted [24]. "It is no longer possible for peer review to function as it once did – there just aren't [sic] enough qualified reviewers to do it" (p. 2) [24]. The author strongly suggested that institution only require authors to publish once- twice a year and this will help cut down on using predatory publishers [24]. In order for a change to happen in the field of publishing, it will have to start on the university level by changing the requirements.

Certain countries seem to proliferate more predatory publishers; for example, researchers found that journals published in India might not be peer reviewed [46]. Some scholars and librarians have published assistance for scholars to help them determine whether a journal is reputable. The various publishing options available to researchers, as well as how to determine whether an open access publisher, is disreputable [18]. Beall constructed a foundation upon which researchers can evaluate potential publications before submitting their papers [10]. The metrics include:

- Editor and Staff. Avoid publications where the owner is identified as the publication's editor; no academic information is provided for the editor, staff, or board members; journals have duplicate editorial boards; an insufficient number of board members; or there is little geographic diversity among the board members.
- Business Management. Avoid publications that seem to have a lack of transparency in their publishing practices; has no mention of digital preservation; has a large number of journals; hides the author's fees; sends an unanticipated invoice after publication for extra fees; search engines cannot crawl through the contents; or locks their publication in a PDF format (harder to check for plagiarism).
- Integrity. Does the name of the journal match the mission of the organization? Read carefully to ensure references to countries align with the affiliation of the editorial staff; beware of awards, etc., posted on the journal's web site that claim impact factors; watch for spam emails asking for unqualified peer reviewers; and the publisher neglects to devote enough resources to discourage author misconduct.
- Other. Other predatory practices might include publishing papers that were previously published without mention of proper credits; language that claims the publisher is a leader or other accolade; published papers that are not written by academics; and the contact information does not list a physical address.

Beall maintains an up-to-date list of predatory publishers and an associated blog at http://scholarlyoa.com/publishers/. He has reviewed specific predatory publishers in depth and has also identified specific scholarly open-access publishers [4, 6, 8].

Beall has been criticized for his work in alerting the scholarly community to the predatory publishing situation. Bivens-Tatum [12] reviewed the claims and assertions of the public attack by Beall [17] on OA publishing. He took a philosophical approach to Beall's argument, and stated, "Beall makes a number of outrageous claims about OA advocates without referring to or citing any of them" (p. 441) [12]. His bottom line is that Beall's argument is "neither sound nor valid" (p. 444) [12]. Beall discussed various viewpoints on his work in an interview:

> Others tell me that their organization uses my Web site and list of predatory publishers in different ways. For example, one organization won't fund any article processing fees for the publishers that are on my list. On the other hand, I get some negative reactions, especially from Europeans who have a lot invested in the gold open access model. Some of them tell me that they think I'm exaggerating the problem or say that it's not as big of a problem as I make it out to be. And they say that any competent researcher is able to judge for himself whether a publisher is a good place to publish, so that my list isn't really needed. (p. 125) [55]

Beall pointed out in this interview that the gold open access model can be considered a scram for publishers to get money from authors or grant money from institution [55]. Making profits are these types of publishers' number one concern. They are not interested in the reader gaining knowledge. Of course, Beall is not stating that the model is entirely bad. But, publishers have taken advantage of the situation by using the Internet. Most articles are published quickly so peer review of the article is limited, if at all. Knowing the location is one of the key instances that can tell an author that it is a scam. Most predatory publishers do not list were they are located or who is in charge and how long they have been doing it. According to Beall, authors are required to do intensive research about publishers before submitting any works. Beall has established a blog to help author's eliminate predatory publishers, but it is still the author's responsible to check even farther [5].

Schwartz described a lawsuit against Beall by the "OMICS Publishing Group, an open access (OA) publisher based in India" (p. 19) stating that Beall has made false claims and made offensive postings on his blog [52].

5 For Profit Schools

In order to situate the context of this study, an overview of for-profit schools is warranted. Postsecondary institutions that earn profits from their students' tuition and fees are somewhat different from public colleges and universities, which receive some of their funding directly from local or state funds, as well as from private nonprofit schools, which have their own funding sources. The for-profits' increasing impact on the higher education landscape is difficult to ignore; they "employ somewhere between 140,000 and a million faculty" (p. 35) [11].

For-profit schools have existed in the American education system since the mid-1800s [25], and although they are relatively expensive, they comprise the fastest-growing sector of higher education in the United States [21]. For-profit colleges are able to fill a gap when public or private non-profit universities cannot meet the demand for higher education, which is an issue in developing countries as well as in the United States, due to state budget cuts in recent years [23]. They open up opportunities for higher learning to students that might not otherwise be able to earn a college education. Access to higher education is limited in developing nations [3, 21]. Various social factors in America make people with various social factors less likely to earn a college education, such as holding a minority status, earning a low income, being functionally illiterate, or raising children alone [21, 51]. For-profits cater to people in these disadvantaged groups.

On the downside, the overwhelming majority of for-profit college students rely on financial aid to fund their education, and they have the highest student loan default rate of any American higher education sector [51]. For-profit students' graduation rates tend to be low [43]. "The University of Phoenix's 'Online Campus' has a national graduation rate of only 5%" (p. 256) [23]. For-profits have been the target of many lawsuits for issues such as illegal recruitment tactics and illegal misuse of student aid, a fact which has decreased their political standing [11]. Berry and Worthen advocate for the unionization of for-profit faculty members, since they cannot earn tenure, they possess a lower status than professors at elite universities, and they commonly hold unstable adjunct positions [11].

The mission and focus of for-profits differs from more traditional schools. They center on career training, especially in high-demand areas like business and information technology [26]. This differs from traditional universities' missions that center around creating new knowledge and performing original research [30]. For-profits develop classes through the use of student learning outcomes and centralized curricula [21, 26]. For-profit employees' time centers almost entirely on the student experience, including recruitment, job placement, retention, student services, high instructional quality, up-to-date course content, and convenience [21, 30, 38, 43, 51]. Interviews with senior administrators at for-profits revealed a "customer service" approach to student relations; "serving students seems to hold an elevated status in the for-profit sector" (p. 271) [38].

For-profit faculty members spend the overwhelming majority of their time on teaching [26]. They "seem to be relieved of the necessity for research and publication" (p. 572) [21]. For-profits also tend to provide less support for their libraries than traditional universities do [21], which can impede the intellectual growth of its students and faculty. Barandiaran describes Universidad Andres Bello (UNAB), a for-profit research university in Chile. This university works to generate research output at a rate similar to traditional universities because it views research as "good business" (p. 213) [2]. Research must benefit a for-profit school politically and/or economically for it to be institutionally supported. UNAB's mission is different from a traditional university, as explained in the following quote:

> While we seek to be equally demanding, to publish in the same journals and patent just like the rest, our objective in doing research has only to do with cultivating a

> cutting-edge academic atmosphere… The difference has to be clear: a research university—unlike what we do—has to be accountable to society and to the world, of its contribution, which is massive. That is not the purpose of our university, that is not its essential mission [2].

6 Problem Statement

As discussed in the literature review, it can be difficult to determine whether an OA journal is reputable or predatory. In some larger for-profit universities, full-time faculty have a publication requirement, although a lower rate of research output is expected from them as compared to research university faculty. Their faculty members face challenges that may impede their ability to publish in the highest ranked scholarly journals in their fields. For example, for-profit faculty members in the United States are not allowed to apply for federal research funding, which makes it difficult to purchase lab equipment and data analysis software, hire research assistants, travel to conferences in order to present findings, or pay to publish in gold OA journals. A lack of an ingrained research culture means that junior faculty cannot consult with senior faculty about where and how to publish research in respected journals.

This paper presents a case study of faculty members who work for large for-profit American universities that awards associate's, bachelor's, and master's degrees. Most of its instruction is provided entirely online. Like other non-profits, this university emphasizes teaching and students above all else, but its full-time faculty members are evaluated on the areas of teaching, research, and service, as they are in traditional universities. The university has a competitive internal research grant program, but most funded proposals investigate how to improve teaching and learning at the university rather than on creating new knowledge in the faculty members' academic subjects of expertise. All these limitations may make it somewhat unlikely that their professors will be able to publish in highly-ranked peer-reviewed journals since they lack the time and the financial resources necessary to conduct studies worthy of publication. To this end, the research questions are as follows:

- How often do full-time for-profit university faculty members publish in peer-reviewed publications?
- What do full-time, for-profit university faculty members know about OA publications?
- How often do full-time, for-profit university faculty members publish in OA peer-reviewed publications?
- Where do full-time, for-profit university faculty members publish their research?
- How do full-time, for-profit university faculty members determine whether a scholarly publication is reputable or predatory?

7 Research Methodology

The researchers used a qualitative survey method called Qualtrix. Researchers gathered data through full-time faculty that were found through social media, such as Facebook and Linkedin.

8 Summary of Data

A total of 43 responses were received from the survey conducted and all the responders were over 18 years of age. Of these 43 participants, 4 were between the ages of 26 to 35 years for 4%; 14 of the participants were between 36 to 45 years old at 19%; 14 of the participants were of ages between 46 to 55 years old, which was 33% of the total number of the participants. The majority of 17 participants were from the age group between 56 and older.

On the other hand, there was no response from the age group between 18 to 25 years old. Interestingly, in a question to the participants on how many years they have been teaching at a for-profit institution, a large majority of the responders, 19, indicated that in such institution for between 11 to 15 years. This was followed by 12 responders who stated that taught in the for-profit institution for 3 to 5 years; whereas 5 of the responders indicated 11 to 15 years, which represented 11% of the total responders and matched the 5 who indicated they have taught in the for-profit institution for 1 to 2 years. Only 3 of the participants, a 7% of the total participants said that they have taught in the for-profit institution.

Twenty-five out of the 42 participants reported to be full-time faculty, which represented 60% of the sample population. The remaining 17 of the participants report as part-time faculty, which was 40% of the total participants. Overwhelming 100% of 44 participants confidently responded yes and non-responded otherwise.

The respondents provide broad responses to their definitions of peer-reviewed literature. Seventeen of the participants did not know the definition of predatory publications nor open-access publications. When asked the definition of a predatory publication, 28 responses included a publication without an editorial board or a biased editorial board, a publication that charges authors a publishing fee, or no idea at all.

When asked the definition of an open access publication, the answers were too diverse to quantify. Responses included one that allows users to publish without a fee or a subscription, web based that publishes all subscriptions, free access, and publishers that allow no peer reviewed work.

When asked the difference between an OA journal, 22 responses included both run articles through a review process but proprietary journals typically charge a fee for access, easier to publish and access, open access is not copyrighted, cost, and 5 participants said they did not know.

There were diverse responses to the following questions:

- How do you decide whether you would like to publish in a particular journal?
- Does your university provide guidelines regarding acceptable journals?
- How do you determine whether a journal is considered reputable?

- What, if anything, would set off a red flag in your mind that a journal is not reputable?
- Who do you think pays for your university's access to peer-reviewed journals?
- To the best of your understanding, why are some journal freely available online while others are not?
- Who do you think should pay for the cost of publication and the cost of accessing journals?

When asked how much are you willing to pay out of pocket to publish in a peer-reviewed journal over 75% said they would not pay to publish.

Participants were unclear as to how to select a publication to publish in. Most of the participants were either unsure if their university provided guidelines on acceptable journals. Typically, participants considered a journal reputable if it was well known in their respective fields of interest.

The largest group of participants felt that if they had to pay to publish or if a journal did not have a peer-reviewed process these were indicators that the journal may not be reputable.

9 Limitations to the Study

Due to the few participants in the study, this was a limitation to the research. Although the results show that there should be further research, a larger pool of participants should be included.

10 Future Research and Conclusion

Future research efforts might include a larger sample of research participants in an effort to extrapolate the results to a general population of full-time faculty working in the for-profit universities. Until the "publish or perish" culture changes, full-time faculty will continue to be required to publish. The data suggests a significant number of the research participants did not know the definition of predatory publications or open-access publications. Education on how to assess whether or not a publication could be considered predatory could be helpful in assisting faculty navigate the massive world of publishing options.

Understanding the specific research requirements for each for-profit university might help the faculty member determine whether to publish in an Open Access (traditional, gold, green, and platinum) publication or in the more traditional scholarly journals. Further, understanding each for-profit university's philosophy on publishing online or in print could also aid in helping faculty determine where to publish.

The damage caused by predatory publications is limited to certain areas especially in the developing and emerging countries. Open access is growing due in part to the increase actions of major research funders and policy makers. However, it is believed that as they are exposed in the developed countries, their growth will be limited in the very near future. The awareness created by different sources such as ours, should create better opportunities for researchers to be more cautious in the developing and emerging countries, where predatory publishing organizations are dominant with low cost of publications. In order to move our science forward, we need to be wary of predatory publishers. Greater education is needed for new researchers on how to identify non Scholarly and Peer Reviewed journals that reflect best practices in publishing.

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Criteria for Selection of a Web 2.0 Tool for Process Modeling Education

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Abstract. Collaborative learning activities can raise students' motivation and help them to achieve better results. Faced with many available tools that support these activities, teachers need to choose the most suitable one. This paper presents a criterion-based procedure for selection of a Web 2.0 tool for collaborative activities in the domain of process modeling. The procedure defined a set consisting of domain specific criteria and general criteria important for assessing Web 2.0 tools for any application domain. The importance of each attribute included in the criteria is expressed numerically using weights. The established criteria are applied to nine Web 2.0 tools intended for diagramming in order to select a tool that will be used for process modeling education as part of the e-learning environment consisting of Moodle LMS and the educational recommender system ELARS.

Keywords: Collaborative learning activities · e-learning · Web 2.0 · Process model · ELARS

1 Introduction

One of the subjects included in the education of future software engineers is business system analysis. By using different elicitation methods, analysts extract knowledge and requests from users and, on the basis of the knowledge about the business system, create process model. To be successful in this field, students should acquire theoretical knowledge, as well as communication and collaboration skills essential for teamwork. In order to raise students' motivation to learn, achieve better academic results and gather more knowledge about the subject matter, educational process should be enriched with new and interesting contents and collaborative learning activities, such as collaborative modeling [1, 2].

Commercial solutions for collaborative process modeling can be unavailable to universities or students due to high cost. There is a range of Web 2.0 tools that can be used as alternative since they have potential to enhance collaborative modeling activities [1, 3]. Web 2.0 tools offer many possibilities that can enrich teaching and learning process. These tools have less functionalities than commercial tools, but are inexpensive or even free. Faced with many options, teachers have to choose the most suitable tool for realization of planned learning activities.

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This paper presents a research that aims to provide a criterion-based procedure for selection of a Web 2.0 tool for collaborative learning activities in the e-learning environment consisting of Moodle LMS and the educational recommender system ELARS [4]. The procedure includes a set of general criteria important for educational environment, as well as a set of specific criteria related with the specific domain of process modeling. If applied to selected Web 2.0 tools, the procedure indicates the most suitable solution.

2 Background

In order for students to develop practical skills needed for process model design, during their education they will solve practical assignments such as requirements gathering (interview, document analysis) and drawing of data flow diagrams of different levels. Our prior teaching practice included individual design of process models through a number of paper-based assignments. Considering the benefits that collaboration may bring to students' learning and the fact that using paper-based medium might limit the way in which participants can contribute to model building during collaborative modeling [5], students could benefit from learning activities like collaborative modeling/diagramming which are performed using collaborative modeling tools [2].

In practice, collaborative modeling is performed during development of complex information systems by a number of team members which actively contribute to the creation of a model [5]. In that process, as well as during communication with users, team members need to use adequate social skills. It is important to develop these skills during higher education by creating opportunities for students to communicate, elaborate and defend their opinions [6].

Traditional approach to process modeling in software industry assumes using of commercial tools that are installed to our computer. Since their price is rather high, they are mostly used by companies that need safe software with high quality and support. Higher price usually means plethora of useful features, options that support professional and complex diagramming, and possibilities for creating different sorts of diagrams. These tools offer modern design, collaboration support for larger teams and versioning. Programs such as Microsoft Visio [7], SmartDraw [8], Flowcharter [9] and Edraw [10] are some of the most popular commercial tools for process modeling.

Other than commercial tools, support for students' activities during teaching and learning can also be provided by Web 2.0 tools [3, 11, 12]. Web 2.0 tools have many features which enable students to become active participants of a learning process. Web 2.0 tools support social networking, interactivity and communication and also help in harnessing collective intelligence [13]. Examples of such tools are blogs, wikis, social networks, etc. [3]. The use of Web 2.0 in education can result in students' higher engagement and more interest and courage to contribute [14]. Since there are numerous available tools, teachers need to consider many options and have the obligation to make the choice that will enable achievement of learning outcomes.

3 Research Methodology

To support decision making about the Web 2.0 tool that will satisfy the needs of the process modeling education, this research determined a list of relevant attributes. The list includes attributes referring to general features of Web 2.0 tools and domain specific attributes like available shapes to draw parts of the process model (concepts). Special attention was paid to the fact that the selected tool will be used for collaborative learning activities.

The importance of each attribute included in the criteria is expressed numerically using weights. For each criterion and each Web 2.0 tool it should be estimated does the tool satisfy it fully (2 points), partially (1 point), or not at all (0 points). Then, weights of each criterion should be applied to the number of points. The calculated sum of points represents result. In order to select the most suitable tool, comparison of results should be made.

Domain related and general criteria are described in the reminder of this section. General criteria can be used for assessing Web 2.0 tools for any application domain, but each application domain requires specific criteria. This paper deals with the process modeling education so it elaborates the criteria considered for that application domain. Weights used to calculate results can be readjusted depending on the attribute relevance. It is possible that some criterion is extremely relevant and recognized as strictly needed. In that case, it should be used as key criterion to exclude some of the tools that do not satisfy it. In case that more than one tool reaches the highest number of points, more detail analysis should be performed. It is recommended that points assigned for the most important features (those with the highest weight) are compared.

3.1 Domain Related Criteria

Predefined graphical concepts (library) for process modeling – This criterion is concerned with the library with predefined graphical concepts. Four basic concepts are used during process modeling, according to DeMarco and Yourdon [15, 16]: data flow (line or vector), process (ellipse or oval), external system (rectangle) and database (two parallel lines), as shown in Fig. 1.

Fig. 1. Basic graphical concepts for process modeling

Database symbol: two parallel lines – This criterion is relevant if the tool does not have process modeling library. In that case, symbols found in general library can be used. This does not pose a problem for the process (ellipse or oval symbol), external system (rectangle) and dataflow (line). But database represented by two parallel lines cannot be found in the general library. Therefore, it is considered a separate criterion. This criterion is characterized by low weight factor, because users can invest some effort and draw their own symbol using line and text label, or import it as an image instead. Other methodologies use another symbol for database representation: a cylinder. Cylinder is one of the basic concepts in the general library and in case of following such a methodology, this criterion is not necessary.

Adding connectors to shapes – In order to establish a connection between shapes, connect points are used. Manually adding connectors to shapes enables creating a larger number of contact points between shapes and that benefits to the clear view on the model, less switching of the lines, user receives a more dynamic response when he/she changes position of one shape on the model, etc. This attribute facilitates diagramming process.

Adding text to shapes – Each object (concept) on the model should have a name. Therefore, it is important to have the possibility to add text to each shape.

Image import – In case of a missing graphical concept, image (concept) import may be very important. Image import can be from the computer, from the Web or from other tools for process modeling, such as Microsoft Visio. This criterion enables personalization of diagrams by using personal shapes and images that can positively influence the diagram appearance.

Export to other formats – After finishing the model, it should be documented in the most suitable format, such as portable document format (PDF), or image format such as JPEG or PNG. Any diagram created online after the export to other format can be used independently of the Web 2.0 tool that was used for its design.

3.2 General Criteria

General criteria cover functionalities needed to support communication and collaboration during teamwork, as well as version control.

Number of files – Each account registered within the Web 2.0 tool has the possibility to create a certain number of files (documents, presentations, maps, diagrams, etc.). Transition to paid version of the tool usually raises this number. When assessing this criteria, tools that support at least 5 files are graded with maximum number of points, tools that support at least 3 files are graded with medium number of points, while tools that support less than 3 files are graded with zero points.

Comments and notes – Making comments and notes is helpful during the process of finding the best solution between several available ideas.

Number of collaborators – Criterion concerned with the limited number of collaborators is important, but usually the limit can be superseded with transition to paid model of Web 2.0 tool. When assessing this criterion, tools that support unlimited number of collaborators are graded with maximum number of points, tools that support at least 3 collaborators are graded with medium number of points, while tools that support teams with less than 3 collaborators are graded with zero points.

Real-time collaboration – This attribute refers to the support to simultaneous work of a number of users. This criterion is essential for team collaboration because with it organizational efforts are diminished.

Communication between collaborators via chat – This attribute ensures an environment in which collaborators can comment their work and work of others and express their own attitude and ideas (in a form of written conversation).

History – This feature ensures the tool will remember every change made and enable users to return to any older version. This criterion is important for team collaboration, but also for individual work to facilitate error correction and desirable changes.

Individual contribution – This feature is very important for education in case teacher wants to assess contributions of individual students to the final results. The most articulate view for assessment of individual contributions will ensure review of individual activities of each team member. The teacher should be able to see to what extent each team member contributed to the final solution.

User help and support – This criterion deals with detail user manual or tutorials in written or video format provided on official tool webpage. In general, user support can be provided via e-mail or online forum intended for additional information and advice to the users, in case of any problems during their work.

Desktop version – this feature serves for faster access to the tool without the need to open web browser.

4 Research Results

The criterion-based procedure for selecting the best-fitted Web 2.0 tool for collaborative process modeling was applied to nine Web 2.0 tools intended for diagramming. These are Gliffy [17], Creately [18], Cacoo [19], Draw.io [20], Lovely charts [21], Flowchart.com [22], GenMyModel [23], ProcessOn [24], Diagramo [25]. This analysis assessed the level of supported features in basic free versions of the tools. Web 2.0 tools in their free version usually have some limitations that will more or less influence the diagramming process. Additional fee removes these restrictions. Prices for basic paid version range from 5 USD per month.

Although upgrading to paid versions offers more possibilities, in this research the existence of free version was used as key criterion. Research results are shown in Table 1. Weights assigned to each criterion are shown in parenthesis, following criterion name. Criteria indicated as partially satisfied (1 point) can be covered with qualitative description as well. For the tools analyzed in this research, qualitative analysis is given below.

Cacoo does not have the library with predefined graphical concepts, but it is possible to download Data Flow Diagram Stencil from Cacoo store (uploaded by other users). Database symbol can be found in the same stencil.

Table 1. Research results

Web 2.0 tool **Criteria (weight)**	GLIFFY	CREATELY	CACOO	DRAW.IO	LOVELY CHARTS	FLOWCHARTS.COM	GENMYMODEL	PROCESSON	DIAGRAMO
Domain related criteria									
Predefined graphical concepts for process modeling (3)	0	2	1	0	0	2	0	2	0
Database symbol: two parallel lines (1)	0	2	1	0	0	2	0	2	0
Adding connectors to shapes (2)	2	2	2	2	2	2	2	2	2
Adding text to shapes (3)	2	2	2	2	2	1	2	2	2
Image import (1)	2	2	2	2	2	2	0	2	2
Export to other formats (1)	2	2	2	2	2	2	2	2	2
General criteria									
Number of files (3)	2	2	2	2	0	2	0	2	2
Comments and notes (1)	1	2	0	0	0	0	2	2	0
Number of collaborators (3)	0	1	2	2	0	2	1	2	2
Real-time collaboration (3)	0	2	2	0	0	2	2	2	0
Communication between collaborators via chat (1)	0	0	2	0	0	0	2	2	0
History access (3)	0	2	0	2	0	2	0	1	0
Individual contribution (3)	0	0	0	0	0	0	0	0	0
Help & support (2)	2	2	2	2	0	2	2	1	0
Desktop version (1)	0	2	0	0	2	0	0	0	0
SUM	**25**	**51**	**42**	**36**	**16**	**47**	**29**	**49**	**26**

0 - not satisfied, 1 - partially satisfied, 2 - fully satisfied

Criterion *Adding text to shapes* was assessed as partially satisfied by Flowchart.com because text label on the data flow symbol (line) is not glued to the line, i.e. it does not automatically change position in case of line repositioning.

Number of files is limited in free version of some tools: Gliffy and Creately limit the number of diagrams to 5, Cacoo limits the number of sheets to 25, Lovely charts uses the limit of 1 diagram and ProcessOn 9 private (unpublished) diagrams (with the possibility to increase this number by friend invitations, “likes”, etc.), GenMyModel defined the limit on number of objects to 20 per project and in free version only 1 project is allowed.

Comments and notes are available in Gliffy only on some shapes (data flow and entire diagram are excluded). Lovely chart supports comments only in its Premium version. Creately and GenMyModel, in their free version allow 3 collaborators and free version of the Cacoo tool allows diagram sharing with 15 collaborators.

Criterion *Real-time collaboration* is not part of the free version of Lovely charts, although its Premium version does support real-time collaboration. Assessed version of Draw.io does not support real-time collaboration nor chat communication, but real-time version of the tool does support it (drive.draw.io).

In general, Web 2.0 tools for diagramming do not satisfy the *Individual contribution* feature, but this feature can be compensated with the possibility to access any prior version created by any team member (History access). ProcessOn offers access to history data, only if the version itself is created by the user.

Help and support is indicated as low-level for two tools, compared to others, and as medium for one tool, therefore their grade is not satisfied and partially satisfied, respectively. Medium grade is based on the fact that only short tutorial is available and web site of the tool was adapted to native language and letters of the country it was developed in, without an easy option to change it to English language.

According to the results, the tool Creately turned out to be the best choice.

5 Conclusion and Future Work

Web 2.0 tools can be an excellent alternative for desktop programs since they offer many features. They are easily accessible online and user friendly. Many Web 2.0 tools are free for use, and their full upgrade is less expensive then commercial tools. Free versions of Web 2.0 tools have limited possibilities but they can be the reasonable solution for students and their assignments that need fast and simple diagram design. For more complex diagramming, larger projects and collaboration of large teams, their upgrade is necessary. Criteria-based approach like the one described can help to make the best decision. The procedure for selection of the most suitable Web 2.0 tool presented in this paper may serve as a guideline for any educational domain, especially if the list of criteria is adjusted with domain relevant attributes. The importance of each attribute can also be adjusted by changing weights.

The proposed procedure was applied to the selected set of Web 2.0 tools for diagramming and it resulted with the ranked list. The tool Creately reached the highest number of points. Creately was used as a support for collaborative diagramming during several assignments within the course Process modeling. Preliminary results showed that students participate in collaborative modeling rather than individual activities performed in traditional environment and that Creately satisfied their needs during these assignments.

Future work will include efforts to enable automatic collection of activity data from Creately using ELARS recommender system. ELARS provides personalization of e-learning activities by recommending several types of items (optional e-learning activities, collaborators, Web 2.0 tools and advice). Based on activity data retrieved from Web 2.0 tools using APIs and RSS channels, ELARS estimates a level of student's (group member's) engagement in collaborative activities [12]. Thus, besides personalization, the system can be used to support teachers during evaluation of quantitative aspects of student's work.

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Collaboration Tools for Virtual Teams in Terms of the SECI Model

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Abstract. Nowadays, to participate in a team activity or to collaborate with somebody does not require a physical presence. Virtual settings connect individuals across space and time; allow their real-time communication and collaboration across the globe. It allows formation of virtual teams enabled by the information and communication technology (ICT). Such teams accomplish various functions in work, education and private life. Compared to local teams of physically present individuals, the collaboration in virtual environments requires intensive motivation of the team members, extensive support by their team leader and appropriate technology.

At the same time, no ICT tool is equally suitable for each and every activity. This paper aims to provide analysis of various ICT tools, to disclose their potential to contribute to team's quality communication and to reduce drawbacks caused by impersonal environment. Our aim is to optimize the composition of the ICT supporting infrastructure in order to form successful and effective collaboration.

Keywords: Knowledge management · Collaboration · Virtual teams · ICT · SECI model

1 Introduction

In today's Digital Era, digital environments allow real-time communication and collaboration across any distance. Information and communication technology (ICT) enables the formation and sharing of information and knowledge at long distances in much greater extent than at any time before. It maintains the sense of presence and awareness of remote locations [1] and formatting of dispersed collaborative teams. The members of distributed teams can exchange their needed information in a timely manner and replace their physical "space of place" with the electronic "space of flows" [2]. This technology-enhanced change leads to a wide application of virtual presence in diverse activities: work, education, government and personal life. It has become an integral part of our lives [3] and represents a substantial portion of our daily habits today.

The usage of adequate and satisfactory applications has made virtual communication a central segment of everyday life in companies and organizations [4].

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The technology tools have found their place in their business operations and occupy essential shares of their present functions. For example, the email represents a conduit through which work and its related information are distributed [5] – one can hardly consider a company is not using it. Databases and data warehouses [6–8], knowledge management systems [9–14], intranets [15], instant messaging [16], digital discussion platforms [17], Wikis [18] and other tailored tools support and/or enable their executions.

In late 80's, groupware became a tool for sharing ideas at distance [19, 20]. In the beginning, it referred to "a piece of software with shared access to its data" and identified a computer-based system with social group processes [21]. Nevertheless, it represented an important move from an individual's computer usage to group's practices. On the other hand, team collaboration cannot be limited to the exchange of needed date. The grouped individuals must also participate on their idea's design and development, on exploiting and sharing their knowledge, opinions and experience. The concept of virtual teams has been developing in a stepwise manner towards these concepts. The groupware evolved into computer-based systems that support groups engaged in a common task and now provides a multifaceted interface to a shared environment [22, 23].

From that point of view, virtual teams have to be considered as an intertwined composition of individuals and their technology. For these reasons, our paper is organized as follows: In Sect. 2, we define the concept of virtual team, specify its functions and identify advantages it can bring to companies. In Sect. 3, we point to some drawbacks that may hinder achieving team goals. In Sect. 4, the Nonaka Takeuchi's SECI model [24–26] serves us as a benchmark for covering teams' activities and processes and identifying software tools facilitating their execution. Our methodology covers collaboration tools in business organizations as well as those in academic institutes used for educational purposes. The collected information was then projected into the SECI model structure and discussed. In Conclusions, we summarize our key results, evaluate our approach, and assign its future development.

2 Virtual Team

In this section we identify the differences between locally-allocated teams and the virtual ones and compare them in order to define the concept of "virtual team".

Multinational companies have exploited international expert teams for years. In the past, their personal collaboration on an agreed site was their leading style of work. The global financial crisis imposed travel budget cuts that intensified the trend of going virtually in business operations [4]. At the same time, the advancement of ICT allowed information specialists to participate in IT projects and made it a common practice. The concept quickly spread around various organizations due to outsourcing and globalization and led to ever increasing internationalization of companies [27] i.e. the hypercompetitive business environment have been the catalyst for a new form of working unite – virtual team [28]. Its existence designates an abstract requirement for a group of individuals that collectively possesses certain skills necessary for fulfilling a given task [29]. Most members of virtual teams never meet face-to-face. They rely on email, video and/or phone conferencing, and special network-based collaboration tools supporting their work [30]. The virtual team is an emerging phenomenon with significant implications to the way of working we have known so far [31].

Alike a local team, the virtual team must in the first place be a functioning body. In other words, it is "*a collection of individuals who are interdependent in their tasks, share responsibility for outcomes, see themselves and are viewed by others as an intact social unit embedded in one or more social systems, and collectively manage their relationships across organizational boundaries*" [32]. It is formed by a limited number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they consider themselves mutually accountable [33]. Teams, unlike groups, consist of people with a high degree of interdependence geared toward the achievement of a goal or the completion of a task [3, 34].

The virtual team members interact through interdependent tasks targeted to a common purpose and collaborate through ICT tools in a virtual world [35]. The main characteristic of virtual teams is their strong dependence on technology-mediated communications and limited face-to-face interaction during the completion of their tasks mostly caused by the geographical dispersion of their members [36] – the members can span the world [37]. In extreme versions, team members speak different native languages, are situated on different continents in various countries, interact exclusively through computer mediated communication using a lingua franca that represent a foreign language (mostly English) for all of team members and rarely or never see or even speak to one another directly face-to-face in person [38]. Virtual teams allow managers to summon employees having no formal relation to each other or even do not know anything about each other prior their inclusion [39]. On one side, this allows selecting people with suitable skills and experience, on the other side; it might hinder their future communication as shown below. In principle, more than one group might have the required mix of skills and could play the role of concrete satisfier in a particular (virtually organized) task [29]. As the organizations dispose of a limited amount on resources and try to use them wisely, the virtual teams open new opportunities for people from around the world. The virtual environment diminishes the importance of the place of living and origin – only the performance, skills and character of individuals become important.

In the academic world, several applications form virtual learning environments [40], e.g. the learning open source platform Moodle [41, 42], interactive course materials, labs and quizzes [43] as well as tutorials and simulations [44]. Our research findings show a higher stress on the development of ICT applications in order to make students more confident in their digital competences [45] expecting students to work in virtual teams is becoming more frequent. At the same time, such projects enrich students with experience in a real world of intercultural communication, time zones, time management and virtual teaming [46] presuming that they are cautiously designed and the team members are appropriately instructed [47]. They provide an invaluable experience that can be later efficiently exploited by the students' future employers.

The review of above sources can be summarized as follows:

- Virtual collaboration through a computerized network allows companies to reallocate their resources in accordance to the needs of their business operations. Search for appropriate candidates is no longer bound to the given geographical location.
- Communicating and sharing information, data or knowledge is a team-formative component that often forces its members to leave their comfort zones and expectantly results in a synergy effect.
- The projects can benefit from higher creativity resulting from the team members' cultural and professional diversity. That may lead to significant innovations, increased performance and effort gains.
- Team's virtual collaboration should support perceiving co-workers through their expertise and consequently be less blurred by their personal sympathy, character or unfriendliness. Due to that, discrimination factors caused by prejudices or biases can be reduced.
- All team communication can be protocolled and analyzed, i.e., the effectiveness and efficiency of the problem solution can be studied and evaluated. The lessons learned can be exploited in the future.

We therefore define *the virtual team as an organizational unit which existence indispensably depends on ICT. It is built through a group of people with complementary skills who are assigned with interdependent and inseparable tasks leading to a common goal achieved through their common endeavor and overcoming geographical, cultural and social barriers.*

Some characteristics can occasionally be softened. For example, the team members can sporadically meet with each other. As a rule, such encounters are rather exceptional and the prevailing majority of work and communication runs in the virtual world. The face-to-face encounters are especially recommended during initial stages of durable projects. Even in short-term projects, they usually lead to tighter relations among the team members. Similarly, a geographical distribution is not a must – a virtual team can be built upon a local group applying teleworking.

3 Team Structure and Its Impacts

It is important to stress that practically all factors affecting local ("real") teams can shake virtual teams, too. Naturally, there are some specifics for them – both positive and negative.

3.1 Geographical Dispersion

As the distance between team members grows, the cultural diversity [48] becomes a significant determinant. It impacts the team members' behavior [49] but it may also increase their creativity leading to better alternatives of problem solutions [50–52]. Although the cultural diversity has a positive influence on decision-making, it has a negative influence on communication [53]. Cultural differences result in problems in cohesion formation [54], lead to misunderstandings and cause conflicts [55, 56] as well as deprive mutual trust among team members [57]. Communication challenges based on cultural diversity may affect the teams' ability to engage in a constructive conflict [58] and may transmute it into a dysfunctional one. As a result, even though ICT allows connecting people across locations and enables their partnership, such collaboration is in general not as successful as the collaboration of individuals who are physically sharing the work environment [59].

In specific cases, the partner's identity plays a substantial role in the process, for example in virtual classrooms [60] or when a decision must be made by an authorized individual. The impossibility of his/her authentication may lead into ethical dilemmas or to impossibility to complete the executed process.

3.2 ICT Infrastructure

Another aspect that significantly influences the performance of virtual teams represents the technology itself and factors connected to it: the participant's technological proficiency [61], the used technical tool and/or its system incompatibility [62, 63], technology failures [58], break downs [64] or outages [65–67]. The reliability of applied technology and its level of "user-friendliness" can lead to users' frustration, to a decrease of their performance, to stagnations and even to stopping of the solution process. The use of different or incompatible technology among individual team members can cause difficulties in task execution as well [62, 63].

3.3 Style of Communication

Problems with an insufficient broadband and slow data transfer are frequently solved by using asynchronous communication. When the distributed team relies on it, delays can appear [68, 69]. This can postpone the completion of its task compared to the communication on synchronous base. Asynchronous and, in particular, written communication takes longer and may have a negative impact on team performance, namely, when not all team members are fully proficient in the language used as their lingua franca.

The selectivity and/or omission of some team members in distribution of a particular information (done by an accident or on purpose), leads to unnecessary misunderstandings, conflicts about workflow or frustration within the group. Discriminating information processing caused by its selective distribution (when some team members do not receive certain substantial information) often leads to inefficiency and may have disastrous consequences [70].

Certain omissions in information transfer and distribution are inherent to the virtual teams. The limitations are always present due to the fact that the technology is unable to transmit neither context nor emotions. The inability to transfer contextual information and its type and amount across time and distance represent a major consideration for virtual teams [71]. The contextual factors evoke significant differences between traditional team work and the virtual team work [72] and impact their overall outcomes and performance significantly because the contextual information is a key to effectiveness. In distributed teams, it is identified with difficulties. It may resolve into coordination problems [73]. Furthermore, research results confirmed a relation among team conflict, team performance and contextual information with conflict avoidance and team performance being contingent to contextual information [74].

3.4 Motivation and Leadership

Compared to local teams having physically presented individuals, the collaboration in a virtual environment requires more intensive motivation of its team members and an extensive support by its team leader to maintain the same level of performance effectivity [75, 76]. The members likely miss their regular face-to-face interaction and therefore it needs to be intentionally created [77]. This adds extra load to skills of the team leader. Insufficient and ad-hoc motivation of workers and insufficient support of their collaboration can cause stagnation similar to a strategy loss.

4 Virtual Collaboration and the SECI Model

The collaboration of a *virtual* team has to lead to a *real* outcome. As we have seen, not all barriers to it are objective and rational. For this reason, team leaders have to concentrate on managing both rational and not-fully-rational factors. As [78] shows, the Nonaka Takeuchi's SECI model [24–26] can clarify the importance of not-fully-rational knowledge in the terms of learning processes and, in this way, facilitate the evolution of mutually shared knowledge within teams.

4.1 Explicit and Tacit Knowledge

Knowledge in organizations is generally classified into 2 types: explicit and tacit [79].

- Explicit knowledge represents the portion of our total knowledge we are aware of. As such, it is easier to codify it [80] and, subsequently to digitize. In its digitized format it can be transmitted to others through ICT [81], i.e. it represents a natural and generally accepted part of virtual team's collaborative activities.
- In difference to it, tacit knowledge represents highly personal and context-specific experiences, know-how and skills [82]. It is difficult to codify it, to explain it [80], to formalize it and to communicate it to the others [83]. On the other hand, it is always present as M. Polanyi explained in his famous quote: "*We can know more than we can tell*" [84].

The virtual teams must exchange, exploit and elaborate their both *explicit* knowledge (documents, data, processes, etc.) and *tacit* knowledge (reasoning, personal and/or personalized views, feelings, preferences and others) to carry out their tasks.

4.2 Transferring Knowledge

Data transferred between computers is always explicit because they are represented by (digitally encoded) symbols inscribed by human hands or instruments. The obtained data help to its receiver to resolve a question, to disclose or to reveal distinctions or to evoke a new action [85]. At the same time, data becomes information through its processing and interpretation [86] – by judgements made by an individual or a group. If the team collaboration would only require data exchange, there would be no problems. They appear when the receiver's judgement differs from the original meaning encoded by the sender. The partners then act in accordance to their distinct interpretations. As their believed (but different) interpretations form pre-conditions for their knowledge [87] and become new knowledge through their individual cognitive effort [88], even the smallest deviations may result to dissimilar interpretations. As the processes are unconscious, none of the partners may be aware of his/her delusion. Due to the direct contact of the partners, disclosing it is usually easier in face-to-face environments than in virtual ones. For this reason, it is difficult to determine when data becomes (relevant) information and when this information becomes (relevant) knowledge [89].

Explicit knowledge is being transferred through both ICT and non-ICT methods [90]. It has been confirmed that data emerges only after there was initial information, and that information emerges only based on existing knowledge [88]. Unless these processes are not coordinated ("unified") within the collaborating group, the risk of misunderstanding is present even in the case of explicit knowledge transfer.

Tacit knowledge is primarily transferred by non-ICT methods. Research confirmed that its transfer can be facilitated through personalized communication tools as video and phone records and conferences [91–93] and by email [93] due to transmitting some of their human-oriented features as facial expressions or style of writing.

4.3 The SECI Model

Nonaka's and Takeuchi's SECI model of [24–26] describes the process of knowledge conversion during which tacit and explicit knowledge expands in quality and quantity [94]. It compromises 4 processes known as *Socialization*; *Externalization*; *Combination*; and *Internalization*. It highlights the importance of tacit knowledge and proposes relevant human interventions in order to achieve the desired goal – well-balanced and properly distributed knowledge among the team members. It indicates what the team leaders and members have to keep in mind to ensure a fruitful interaction and to create a team out of a group with the respect to the (full or partial) absence of the face-to-face interaction (Fig. 1).

Originally, software tools have been designed to automate a manual processes or to replace physical artifacts by more malleable and versatile virtual artifacts [94]. With the development of virtual teams, a pool of tools used by their members is growing. Our below categorization and descriptions are therefore incomplete. There are many valuable equivalents and alternatives to those mentioned below.

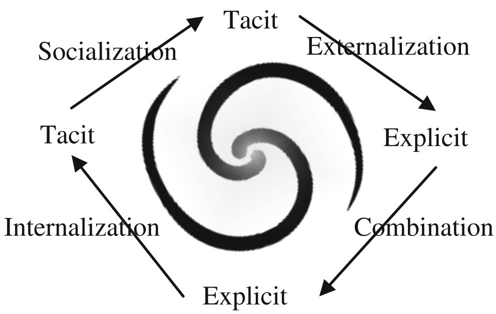

Fig. 1. SECI Model describing process of knowledge conversion

During *Socialization*, tacit knowledge is shared among individuals by converting it into new tacit knowledge [94]. It primarily relies on synchronous communication. In virtual teams, it includes formal and informal talks on strategy, brainstorming, exchange of experience, etc. It can be accomplished by means of video conferences (e.g. Skype [95]) and their records, by live meetings [96] or even by desktop sharing often implemented in Instant Messaging (IM) clients [16] as well as by chatting through IM or digital discussion platforms [17]. Pair programming or a common execution of tasks are another viable options. In all cases, interpersonal dialogues form the center of gravity during Socialization; the role of ICT (if exploited) is only supportive.

In the phase of *Externalization*, the gathered tacit knowledge is being codified into unambiguous concepts [24–26, 91, 94]. This happens by putting down instructions, procedures, schemes, drawings, graphs, Gantt charts and others. Wikis [18] and Intranet pages [15] also allow representing the organizational information in a "neutral way accepted by the community" which then serves as a benchmark for their previously presented tacit knowledge. Notice that asynchronous communication is usually sufficient for these processes. Still, the produced knowledge in its explicit format (a text, figures, tables, charts, …) which has been approved in advance and accepted by all involved. It is recommended to consult their earlier version to make certain that it will be identically interpreted by everyone. These consultations should preferably be done using synchronous means.

In the *Combination* stage, explicit knowledge is systematically processed and then converted into more sophisticated systems [24–26, 91, 94] and possibly elaborated by them. A variety of options starts with aggregating data extracted from databases, data warehouses [97] and repositories (SharePoint [98]) code repositories (e.g. Team Foundation Server (TFS) [99], SubVersion (SVN) [100], Git [101], Mercurial [102] etc.) creating new knowledge using Big Data techniques [97]. The new knowledge produced by its author (regardless whether a human and/or a software tool) is then presented in a (possibly different) explicit data format. Again, this portion of collaboration can be done in an asynchronous way. In exceptional cases, when all Combination-related processes are performed by computers, there is no need for synchronous communication.

Internalization denotes a process of embodying explicit knowledge into individualized tacit knowledge through a series of iterations [24–26, 91, 94]. As the people have problems to comprehend complex explicit data and think in their terms, this last step must always be present. The new knowledge is absorbed as the person's "mental ownership" and becomes an integral part of his/her system of believes and values. As a result, it becomes a part of his/her "intellectual weaponry" and can be used in the next steps as a basis for future development. The internalizations usually run through the interpretation of examples, making analogies, inclusion of the piece into the existing knowledge system etc. "Learning by doing" is also a method of internalization. In virtual teams, it may consist of making product's tests, of visualization of processes, of communicating them to their future users, of checking the programming code for compliance with teams' rules and coding practices (e.g. SonarQube [103]) and many others. This also includes necessary approvals by senior management through review process and accepting their recommendations (e.g. TFS [99]). Whilst personal comprehension of the *Combination* outcomes can be accomplished individually, Internalization embraces a hidden risk. The process should result in the same (or highly similar) tacit knowledge of all team members. Thus, a comparison of their individual considerations is necessary. This lead to their next Socialization – the loop has been closed and may start again at a higher level.

5 Conclusions

As the virtual teams develop new knowledge (in its very broad sense), the SECI model can serve to them as a metaphor. It covers the entire cycle of team's learning from an initial idea (as a rule, vague one), through its specification and elaboration to a final solution accepted by the entire team.

During this process, both tacit and explicit knowledge must circulate among its members. Due to their dispersion, using various ICT support becomes a must. The collaboration tools that must be purchased, implemented, and maintained in their operational mode. At the same time, using incompatible (or badly compatible) tools may have undesired effects. The same holds for wrongly implemented tools and those not used to their full extent. These drawback can result into failures.

To minimize the risk, we classified the functions of virtual teams and their key knowledge transfer steps above. As the information in any digital environment must be appropriately encoded, it is explicit by definition. Its transformation to its tacit counterpart can only be achieved by its appropriate presentation, selection of communication channel, frequency of knowledge exchange, way of synchronization, individual and/or team couching and others. Briefly speaking, the success relies on a balanced solicitation of synchronous and asynchronous communication and on its quality. Their application must be coordinated by the leader who has to oversee both roles and behavior of the team members and to estimate the intensity of the each form of communication during every stage. He/she has to especially control aggravating of undesired variances in their tacit knowledge and its fluctuation because they might lead to the deterioration of the team's mutual knowledge base.

Our proposed framework therefore can serve as a manual for building appropriate environments for virtual collaboration not only in their technical meaning but also as places for interpersonal communication. To achieve it, the importance of synchronous communication is underlined. It is critical during the Socialization and Internalization stages and highly important for controlling Externalization processes. Only the Combination can be (in special cases) completely left to computers. The team leaders have to bear in their mind that the selection of the most appropriate ICT tool for each and every stage of the SECI model and its application must reflect the importance of tacit knowledge.

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Team-Based Projects and Peer Assessment. IT Works!

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Abstract. In order to make the assignments in our Web-design course more attractive for students, the educational strategies of peer assessment and team-based learning were employed. Students worked in teams on a whole-semester lasting assignment – a web application (project) based on their own designs. The project implementation was divided into three phases. After each phase all teams were supposed to submit their work for peer reviewing by other teams. Moreover, students peer-assessed also their team-mates contributions. Following this, each student's score in every particular phase was counted based on her team project evaluation and also the peer assessment she received.

The focus of this paper is on students' acceptance of these innovative peer assessment methods as well as on students' opinions about their possible benefits and usefulness.

Keywords: Peer review · Computer science course · Team work

1 Introduction

One of the pressing problems of higher education in our country is low motivation and poor engagement of students in their study. Students are generally unwilling to participate in any optional activity, although it could be beneficial to their learning. We were also facing this problem in our Web Design course for rather long time. Therefore, already several years ago, we started to look for new and attractive educational methods and activities that could increase the students' interest.

The course in question is a part of master study program in the Applied Informatics but many bachelor students enrol in it usually as well. For a long time, the course was mandatory for master students and optional for bachelor students. In the course of years, various activities (e.g. project, blogging, peer reviewing) in several settings were embodied item-by-item with the aim to increase student engagement and interest in the course topics [3,12,15]. Based on the outcomes of several studies we believed that these activities could be also beneficial to our students in terms of development of their soft skills, and that they could boost constructivistic and social learning [6,13,17,18,22,27]. At the beginning, our students perceived some of the course activities (particularly blogging) to be an extra work and did not take part in them regularly, neither to such an

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extent we hoped they would. Introducing peer review and coupling it with the blogging helped to improve the student engagement in the course activities and the regularity of their work. However, students still objected to writing blog posts. Therefore, two years ago, we replaced the subject of peer review activity – blogging – with an activity which, in our point of view, was closer to the students' interests – a project development. After this shift accompanied also by a few changes in the course settings student engagement in the course work rose and their learning outcomes significantly improved as well. However, students' attitude to the course activities remained still not fully positive. Therefore, in the last course run, we adjusted the course assignments again, modified the project specification and employed peer review in combination with team projects.

Already in previous course runs, our research confirmed that after including peer review among the course activities the learning outcomes of our students improved [1,9]. This years' results [8] showed that the learning outcomes stayed approximately on the same level as in the last two years, thus the overall grading improved in comparison to the years without peer review. Therefore, this paper aims at other aspects of our research – surveying the students' acceptance of peer review as an educational method as well as the students' opinions about its usefulness and other possible benefits.

2 Peer Assessment and Team-Based Learning

To define the process of *peer assessment* we extend the Kennedy's definition [14] of the *assessment* process, by the word "student": *any process where a 'mark', supposedly being some reflection of quality, is awarded by* ***student*** *for some piece of work undertaken by other students.* This definition is based on theories of active learning [21] and andragogy [7], but also on social constructivism [26]. According to Topping [25], peer assessment is defined as *an arrangement in which individuals consider the amount, level, value, worth, quality, or success of the products or outcomes of learning of peers of similar status.* Thus students engage in reflective criticism of products of their peers and provide them with feedback based on previously defined criteria [11].

Students are required to provide grades and/or reviews to their peers on a product of their work or a performance. They are usually provided with help and support from teachers at the start of using peer assessment techniques but it is reduced over time. There are three standard ways how criteria for this kind of assessment are created: criteria are designed by the teacher and students have to accept them; criteria are a product of the teacher's and students' agreement or criteria are identified only by students [4].

According to several studies [5,19,24], peer assessment can be effectively employed in team-based learning. For successful implementation, various methods can be used. However, Michaelsen and Fink emphasize that three factors must be met to fulfil the expectations [20]: a method must be suitable for teams of different sizes, it must correctly reflect the work of the team members and it must support its own significant impact on the course grade.

R.E. Levine described five various methods that can be used in peer assessment applied in team-based learning [16], from which we chose the three most applicable in our conditions:

1. *Michaelsen method.* Students are supposed to assign other members of their teams a score based on their opinion about how much did they contribute to the overall team performance. If there is a seven-person team, each member will be supposed to divide 60 points among her team-mates (she does not evaluate herself) and usually also to give each of them a qualitative feedback. The final score for each student is then calculated as a sum of received points. However, students are required to discriminate among their team-mates. This rule can be very controversial, especially in high-functioning teams where it may lead to gaming the system: students make an arrangement about dividing the points, so in the end each team member has the same amount of points. But as Michaelsen pointed out, if gaming the system is done at the end of a term, it means that all members will probably deserve to have the same score (unlike the situation when it is done at the beginning and after that some students will "loaf").
2. *Fink method.* Students are asked to divide 100 points among their team-mates according to degree each of them contributed to the team work. After that the overall student's score for the assignment is calculated by summing the scores she got from her peers, dividing it by 100 and multiplying it with a group score for this assignment assigned by a teacher. Learners are also usually asked to provide written peer feedback. In this method, those students whose performance was better than performance of other team members, get a score over 100% and those who were not so active get a score less than 100% of the team score. Contrary to the previous method, students do not have to discriminate among their peers. This fact might result in higher students' satisfaction and their responsible attitude.
3. *Koles method.* This method is mostly oriented on quantitative feedback. Students are rated in three areas (cooperative learning skills, self-directed learning and interpersonal skills) divided into nine questions where reviewers choose a value to evaluate peer's skills from following ones: never, sometimes, often, always. Typical skills appearing in this evaluation are: *"Asks useful or probing questions"* or *"Shows care and concern for others"*. On the other hand, students are also asked to qualitatively evaluate their team-mates by answering the following questions: *"What is the single most valuable contribution this person makes to your team?"* and *"What is the single most important thing this person could do to more effectively help your team?"*. The qualitative feedback tends to be more useful than the quantitative one since students are not required to distinguish between the work of their team-mates and usually rate them with excessively high numbers.

Some teachers expect that peer assessment involved in their courses will decrease the amount of their work. However, if peer assessment is to be supplementary rather than substitutional, then there is no time saving and even more extra time and effort is needed. However, it can be beneficial for student as well as for teacher, since both of them have an opportunity to review assessment objectives and purposes, criteria and marking scales [25].

3 Course Activities Overview

The main Web Design course activity is a whole semester assignment - a project. In previous years, the project was uniquely specified - every student was supposed to design and implement her own blog. To be able to test the functionality of the implemented blogs, students were also tasked to provide their blogs with a content, i.e. to publish a reasonable number of blog posts related to the course topics. Aiming to make the students read the blog articles of the others and comment on them, also peer reviewing of blog posts was included as one of the course activities. Nevertheless, blogging was the very activity our students were permanently expressing their displeasure with. Therefore, two years ago, this activity was omitted and peer review was linked with the project development.

Last year, in the newly adjusted course settings the project assignment was also modified [8]: students were enabled to propose their own web application and develop it in a team of 3–4 people. Team-based projects together with a free choice of the project topic were integrated in the course with the purpose to stimulate the development of students' competencies for teamwork and also to enable the students to work on projects they considered to be more attractive. Besides the change in the project specification also the peer review activity changed. Instead of individual peer reviewing of colleague's work the student teams now reviewed the projects of other teams and, in top of that, peer assessment at team level (team-members' work evaluation) was also introduced.

Project development was divided into three sequential phases, each of them submitted independently. Each phase was combined with peer review activity: prior to submitting the project for teacher's evaluation, teams mutually reviewed their projects and afterwards they were enabled to correct their own project according to the received feedback. Later on each student reviewed all her teammates and evaluated their contribution to the project in the given phase.

In order to help the students with reviewing the projects of other teams three structured review forms (one for each phase) were prepared. Every project phase was related to a different set of goals, therefore the questions in each form varied. For better understanding, all questions were supplemented with extensive hints. The reviewing team answered each question with a rating on Likert scale 1–5 (where 1 stands for *very poor* and 5 for *excellent*), and with a verbal justification as well.

For the team peer review the Fink method was chosen (see Sect. 2). While evaluating the work of each their colleagues in every phase, students divided certain amount of points among them (according to their contribution to the joint project) and answered the three following questions:

– Contribution summary. Evaluate your colleague's contribution in this round of the project. Summarize what this person has done, and if you are satisfied by his or her contribution.

– Most valuable thing. What is the single most valuable contribution this person makes to your team work?
– What can be improved? What is the single most important thing this person could do to more effectively help your team?

The final student's number of points in each phase of the project was then calculated with respect to the points gained from her team-mates in peer assessment. This rule was not used in the very first phase, since it served as a training phase only.

The deadlines for submissions, reviews of other teams' works and team peer reviews were strict. The team which missed the submission deadline, was not allowed to review other teams' work in the given phase. The time for reviewing was set to approximately 3–4 days. Afterwards, the teams could correct their projects according to the peers' comments during next few days. Only after this phase the projects were submitted for the teacher's evaluation. The team peer reviewing began after this final submission and students had 5 days to review and assess their team-mates.

We supposed that thanks to these changes students would be more contended with the main course activity, more engaged in it, and willing to spend more time working on this assignment. Moreover, while developing the project and peer-reviewing the work of the other teams, they could gain better insight into the course topics that could result in their better learning outcomes and more positive attitude to the course. The internal team peer review should support the students' self-reflection, encourage the teamwork and also help the teacher to evaluate the work of particular team members.

4 Results

During the exam period of the last semester (winter 2015) students were asked to answer a questionnaire focused on three main issues: peer review of projects, team peer review and students' evaluation of the course. In this study, we investigate the students' attitude to peer review with projects, thus we focus on the first two parts of the questionnaire only. The questions in the first part of the survey were very similar to those used a year ago [8], with only minor fixes included. The second set of questions was used in this questionnaire for the first time.

The response rate in 2015 was 94.74% (that equals to 36 out of 38 students who finished the course), while in the previous survey it was 98.18%. As the base for finding the response rate in both years we used the number of students who attended the final written exam, thus not the overall number of students enrolled in the course. This was because those students, who did not participate at the final exam, had no opportunity to respond to the questionnaires.

4.1 Peer Review Between Teams

The results of the first question in this part of our questionnaire – *What were benefits of received peer reviews for your team?* are comparable to those gained in the

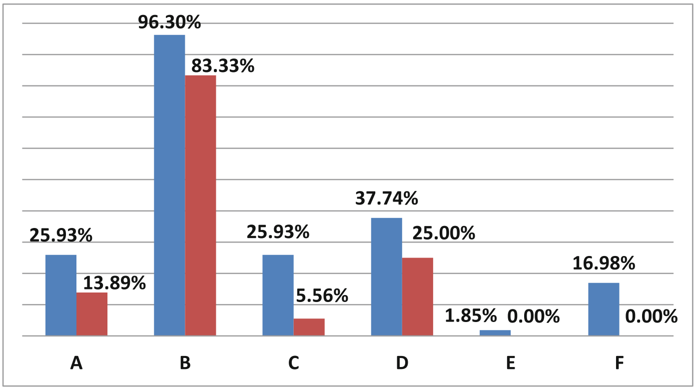

Fig. 1. What were benefits of received peer reviews for your team? A: to better understand project assignment; B: to correct omitted deficiencies; C: to correct deficiencies we were not able to solve; D: to improve in my reviewing; E: nothing; F: other. 2014 2015

previous course run in which projects were peer-reviewed (Fig. 1). When answering this question the students could choose more than one option. Although the percentages are lower than a year ago, the answers distribution is very similar. Again, the highest number of students (83.33 %) appreciated the opportunity to correct omitted deficiencies. Moreover, no students chose the option *nothing*, that we count for a positive sign.

Comparison of the projects completion between years 2014 and 2015 showed us that projects of individuals in 2014 were more completed when submitted for the peer review than team projects in 2015 (Fig. 2). This could be caused by the fact that even if just one member in a team did not accomplish assigned part of the project, the whole project was not finished on time. Thus the number of unfinished projects relatively increased.

Consecutively we asked the students about their experience with unfinished projects. The options available in 2015 slightly differed from those of 2014, however, the differences in the frequency of votes of the same options were incredibly low. As it is depicted in Fig. 3, most of the students in both years were reviewing other teams projects at the same time as unfinished parts of these projects were being implemented and they did not consider it to be a problem. Nevertheless, about one sixth of all reviewers admitted difficulties during such a process.

Although we believe that students are trained in various professional areas through the peer review, we asked them to define benefits related to the process of peer-reviewing others (Fig. 4). In 2014, we expected the option *I could gain more points* to be the most often appearing answer, because for many students are evaluation points very important as they help them to pass the course. However, the another option – *I realized shortcomings in my project during peer reviewing* earned even more votes (68.52 %, compared to 61.11 % for *gaining points*).

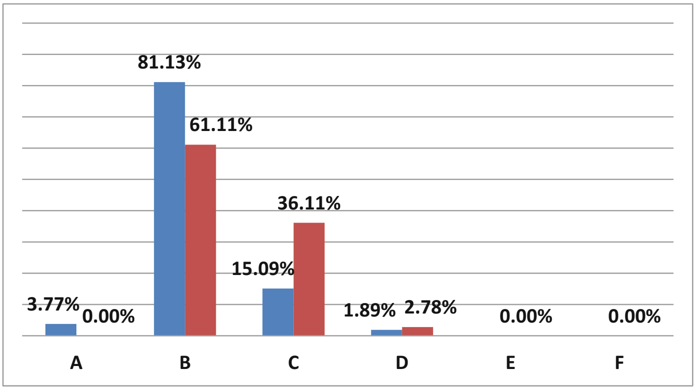

Fig. 2. Were all projects you reviewed finished and prepared for reviewing? A: all finished B: almost all finished C: almost all unfinished D: all unfinished E: it was not my job (available only in 2015) F: our team did not review 2014 2015

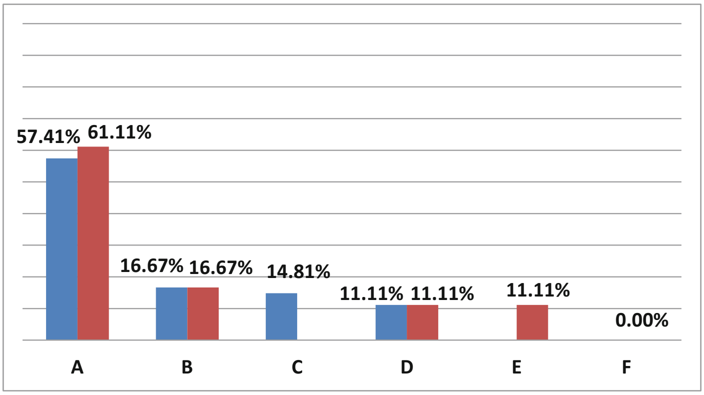

Fig. 3. What was your experience with unfinished projects? A: some peers worked on their projects during reviewing, but it was OK for me; B: some peers worked on their projects during reviewing that caused an obstacle to reviewing; C: I was motivated to work harder on my next project submission (available only in 2014); D: I did not review unfinished projects; E: I did not review because it was other team members' work (available only in 2015); F: our team did not review (available only in 2015) 2014 2015

The results from 2015 varied from those previous in frequencies of particular responses and in the order of most popular options. The most students appreciated the opportunity to realize many different types of mistakes that appear on websites (55.56 %), then 41.67 % of all students liked peer-reviewing because they realized shortcomings in their team's project and the option *I could gain more points* was ranked as the third most popular together with the option *I*

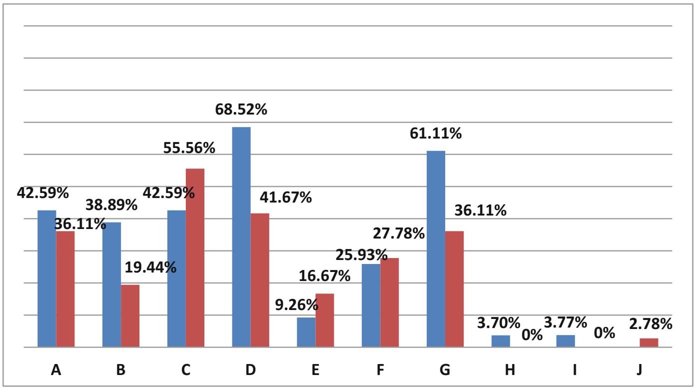

Fig. 4. Do you think that you gain some benefits while reviewing others' work? A: I learned how to test web projects; B: I learned how the project assignment was perceived by other teams; C: I realized how many different types of mistakes can appear on websites; D: I realized shortcomings in my/our project during peer reviewing; E: I trained my verbal skills; F: I improved in constructive criticism; G: I could gain more points; H: nothing; I: other; J: I did not review (available only in 2015) ■ 2014 ■ 2015

learned how to test web projects (both were chosen by 36.11 % of all students). Since this year's adjustment of the course settings involved also the change of the course from obligatory to optional, we suppose that the differences mentioned above could be attributed to this change: if the course is optional, students who enrol in will not be so focused on points as students enrolled in an obligatory course. The fact that no student chose the negative option *nothing* this year, we count for another positive result.

When analysing the students' submissions we realized that although the teams had an opportunity to correct their projects according to the reviewers' advice after the first submission, they mostly did not adopt all obtained recommendations. Therefore we firstly asked how much they modified their projects considering the reviews, and afterwards – in case they have admitted they did not react to all suggestions – we asked about their reasons. As it is shown in Fig. 5, the number of not accepted pieces of advice increased – only 22.22 % of all teams incorporated all advice from reviews, while in 2014 it was 50.94 % of all students. Students in teams mostly agreed with only a few suggestions received in peer-reviewing process of how to improve their projects (63.89 %).

Teams mostly did not correct their projects in accordance with reviewers' recommendation because they had recognized bad advice from their peers (66.04 % in 2014 vs. 60.00 % in 2015). However, a higher proportion of teams in 2015 compared to the proportion of individuals in 2014 admitted lack of time as another cause of not changing the project according to the received reviews. This result is surprising – we would expect the rule "more people working on one

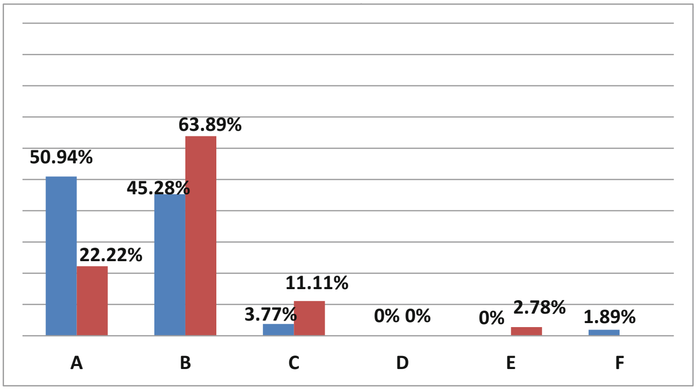

Fig. 5. Did you/your team correct your project according to reviews before final submission? A: yes, everything; B: yes, a half (2014) /yes, but not everything (2015); C: yes, but only a few things D: no, despite criticism I/we did not correct anything; E: I/we had no criticism; F: no answer (appeared only in 2014) 2014 2015

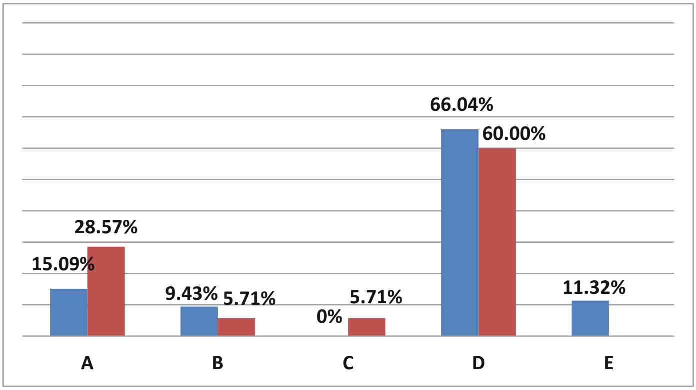

Fig. 6. In case you/your team did not change your project according to reviews, why did you do so? A: We did not have enough time; B: We were lazy to do so; C: It was achieved only with a few points, so we were not interested in correcting it; D: I/We ignored bad advice from my/our peers; E: no answer (appeared only in 2014) 2014 2015

project = less time required" is logical, however, obviously *Brooks' law*[1] fits for this case, as well (Fig. 6).

The opportunity to correct projects according to the obtained reviews before the final submission, was discussed in the last item of this set of questions. The results are comparable with those collected in 2014: students mostly appreciated

[1] "Adding manpower to a late software project makes it later." https://en.wikipedia.org/wiki/Brooks%E2%80%99_law.

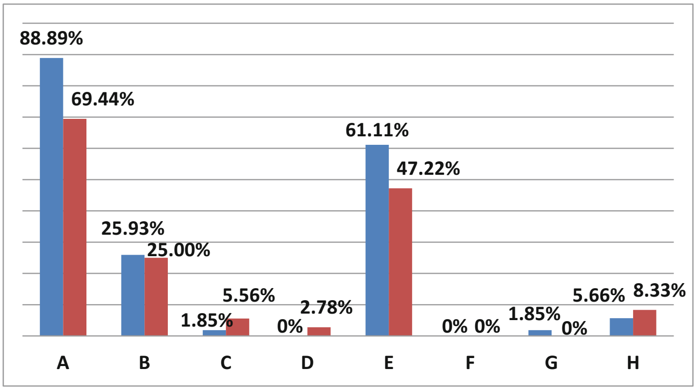

Fig. 7. Do you think that the chance to correct your/your team project before final submission was beneficial to you/your team? How? A: I/We had a chance to earn more points; B: peers gave me/us advice how to remove mistakes I was/we were not able to solve; C: it helped me/us, but they gave me/us bad advice too, and I/we lost points because of it; D: most of peers' advice were bad, it did not help me/us; E: I/we got extra time; F: it was not beneficial to me/us; G: I do not consider submitting projects this way as a fair option; H: other 2014 2015

this feature because of the chance to earn more points for their work (Fig. 7). The other chosen options were not surprising either: students welcomed an extra time they got as well as advice from their peers to problems they have not been not able to solve alone or inside their teams. However, since students could have certain objections against this way of project submission (e.g. they could consider the project to be a product of team-members' work and therefore taking an advice from the others could be understood as cheating, even if accepted by teachers), we included an option *I/We do not consider submitting projects this way as a fair option.* Our assumptions were not confirmed, because none of the students chose this option.

4.2 Team Peer Review and Peer Assessment

In our course the team peer review was firstly used in 2015, thus we had no other data to be compared with the obtained one. Our attention focused on students' opinions about two issues: the process of peer reviewing/peer assessing their team-mates and the process of being peer-reviewed/peer-assessed by their team-mates.

The team peer review and team peer assessment seemed to be more difficult tasks than peer reviewing of other projects, because participants were required to evaluate not only the products of their colleagues' work, but mainly these students' responsibility in their attitude to the collaborative teamwork. In this part of the questionnaire, the students were firstly asked to present their opinions about the process of reviewing and assessing their team colleagues. Although

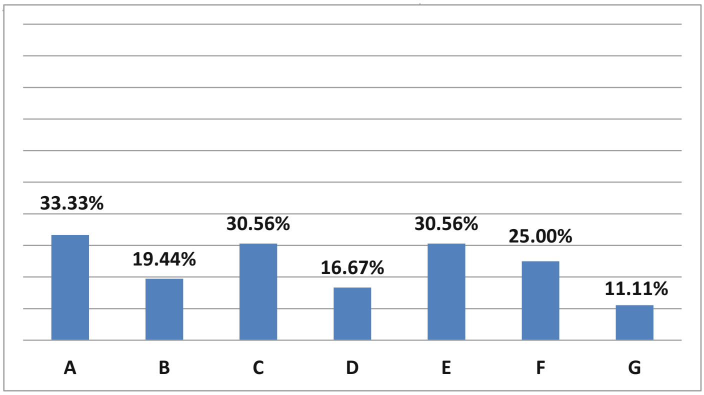

Fig. 8. What do you think about the process of peer-reviewing or peer-assessing other team members? A: it helped teachers in assessing of individuals; B: it motivated my team-mates to better performance; C: I liked it; D: I improved in constructive criticism; E: it was useless; F: I felt uncomfortable while peer-assessing; G: other

the third of the students thought it was useful for the teacher's evaluation of individual's work, only about 30 % of all students admitted that they liked it as well (Fig. 8). Moreover, the same number of students considered the team peer review or peer assessment as an useless activity and 25 % out of all students marked this activity as uncomfortable.

Afterwards we explored the team peer review and team peer assessment from the different perspective: we asked after students' feelings about being peer-reviewed or peer-assessed. The highest number of students (but still mere 38.89 %) commented that they liked this activity, but only 8 % less students marked it useless. However, in contrast to the previous question, none of the students confirmed discomfort while being peer-assessed, what can be considered to be a positive result (Fig. 9).

Students usually have no or little experience in assessment and even if they evaluate others' work with the best intentions, the assessee may consider it as an unfair process. Motivated by Reily who described other four aspects that can influence fairness of evaluation: *retaliation*, *collusion*, *competition*, *laziness* [23], we asked students for their reflection about peer assessing. As it is shown in Fig. 10, the number of students who perceived peer assessment as always fair was as high as 85.71 %. The rest of the students characterized it as usually fair. The option *Never fair* has not been chosen at all.

As it was mentioned before, we employed the Fink method [16] in peer assessment of team-mates. Thus student's overall number of points in each project phase was calculated with respect to the number of evaluation points she got from her team-mates through peer assessment. In our survey we have also explored the students' opinion about this evaluation method.

Most of the students was contended with it, but 20 % of them thought that the distribution of evaluation points this way was not fair (the options *no* and

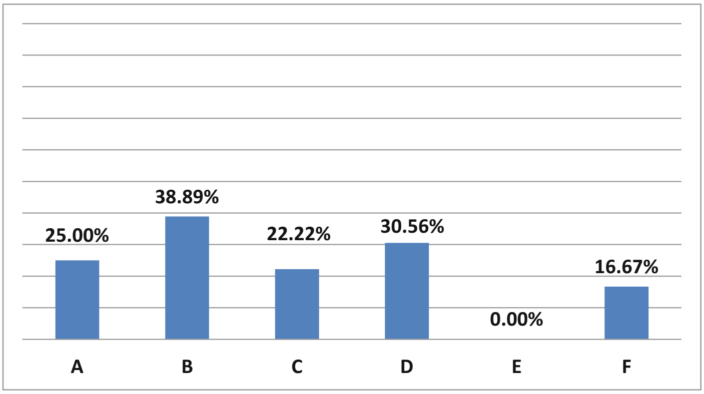

Fig. 9. What is your opinion about the process of being peer-assessed by other team members? A: it motivated me to better performance; B: I liked it; C: I improved in acceptance of criticism; D: it was useless; E: I felt uncomfortable to be peer-assessed; F: other

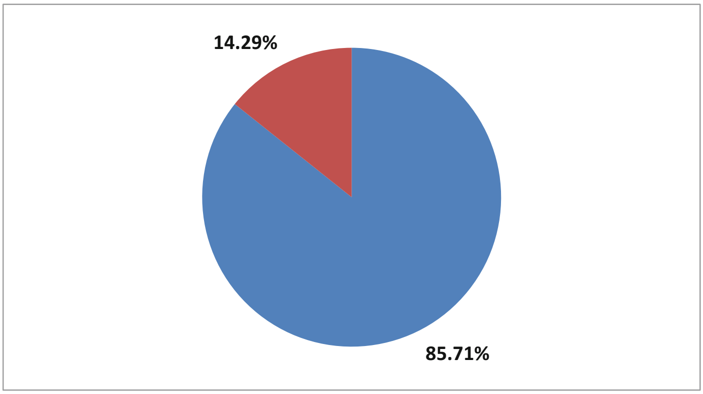

Fig. 10. The way of how you were peer-assessed was: always fair; usually fair; never fair

definitely no in Fig. 11). Since we assumed that this judgement could be more likely caused by the state of being peer-assessed than by the process of peer assessing the others, we calculated correlation coefficient between responses to this question and to the previous one. Unfortunately, the result almost equalled zero (-0.03) which indicates no significant correlation, thus our presumption was not confirmed.

We believe that students' experience from participating in peer review and peer assessment activities is applicable to their future professional and personal life. As depicted in Fig. 12, nearly 70 % of all students share the same opinion.

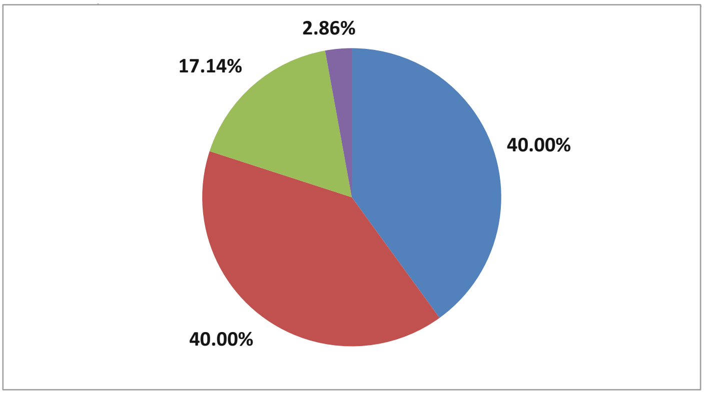

Fig. 11. Do you consider the way of distributing points among team members (in the 2nd and the 3rd phase of the project) to be fair? ■ definitely yes; ■ yes; ■ no; ■ definitely no

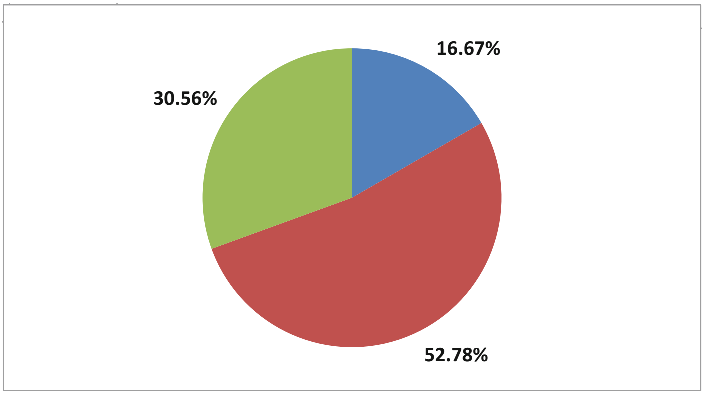

Fig. 12. Do you think that experience obtained in peer-assessing process can be applied in your professional life? ■ definitely yes; ■ yes; ■ no; ■ definitely no

However, the number of students who responded negatively (although they did not choose the strongest negative option) was also rather high.

5 Conclusion

Integrating peer review or peer assessment in a computer science course at the university level can be rather surprising for students. Most of them see the IT professions as positions requiring skills only in analysis, design, programming or testing. They do not consider interpersonal skills (e.g. the ability to present and discuss one's own opinion, the ability to participate in constructive criticism, etc.) to be important ones. Despite these naive presumptions, we began to include these modern teaching approaches in our Web design course several years ago [8].

After introducing them, our high expectations were not achieved. Although a much higher number of students participated in course activities than before and their learning outcomes also improved, students did not accept peer review as enriching and beneficial activity [2,15]. It was mostly taken for a difficult, worthless and time-wasting task. However, as our subsequent research from 2012 and 2013 showed, the main problem did not lie in the peer reviewing itself, but in the type of tasks used for peer review - at the time it was writing blog posts [1,2].

Therefore, next years, publishing of blog posts was cancelled and the peer review activity was focused on the main course assignment – the project [9]. In the last run of the course several changes were adopted to the project assignment and also to peer review activity. The project turned to team-based project: students in teams of 3 to 4 people proposed their own web application and developed it in three predefined phases. After the submission of each project phase, they reviewed other teams' work and peer reviewed their own team-mates as well. Based on the comments received in peer reviews, the teams were allowed to improve their projects, and only after this phase the projects were submitted for teacher's evaluation.

The last run of the course adjusted as explained above was subjected to a close investigation from several points of view. The results of two surveys published in our other works [8,10] confirmed that learning outcomes stayed on a comparably good level while students acceptance of the course and course activities improved. Moreover, the survey presented in this paper showed that students considered peer reviewing of the others to be an useful activity with various benefits. On the other hand, for many of them the process of peer reviewing of their team-mates was a meaningless and awkward task.

Nevertheless, the team-based work was an interesting experience for our students. In our opinion, individuals perceived peer-reviewing of the other teams' work as a quite simple task because they have mostly accomplished it jointly with their team-mates. On the other hand, even if they felt uncomfortable while reviewing and evaluating their friends' work, this skill is expected by their future employers and therefore they need to gain practice in this area as well.

Based on our several years experience and on the outcomes of this research we can confirm that peer reviewing is an useful educational activity that can be successfully implemented also in courses for informatics or computer science students. When it is properly combined with other appropriate course activity, it is not only beneficial for students but also well accepted by them.

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Role of the Online Tutor in Establishing Social Presence in Asynchronous Text-Based Collaborative Learning Environments

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Abstract. The main objective of this paper is to provide a better understanding of the online tutor's role in establishing and maintaining the feeling of social presence among the participants in asynchronous text-based collaborative learning environments. The context of the study is a distributed online course involving groups of participants who do not have a shared history of working together. The data were collected from a student survey and follow-up interviews. The study shows how the online tutor's facilitation in such environments is crucial, and several practical implications for online tutors are presented. In addition, complementing the asynchronous text-based learning platform with synchronous tutor-facilitated meetings is beneficial for learners in terms of building common ground, receiving instant feedback from the tutor and engaging in more off-task interactions.

Keywords: Computer-supported collaborative learning (CSCL) · Online tutoring · Social presence · Asynchronous communication

1 Introduction

Online students often experience lack of social connection with other participants, since online learning tends to rely on text-based communication and takes place across time and space [1]. Unlike face-to-face interactions, text-based communication lacks non-verbal cues, such as facial expression and posture, in addition to what is actually verbalized [2, 3]. Moreover, asynchronous communication usually implies long pauses and waiting for feedback from peers. This disconnection may affect student performance [4], and socio-emotional support may become critical for reaching the learning outcomes [3].

The feeling of social presence in an online community is one of the keys to promoting collaborative knowledge building [2]. Social presence in online learning is the degree to which an online learner feels connected with other participants in a learning community. The feeling of social presence helps students overcome the feeling of isolation from each other and encourages them to engage in meaningful online learning activities [1], which is especially important in collaborative learning where group-focused dimensions are emphasized [5].

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The features of the communication medium play an important role in establishing the feeling of social presence. When the medium provides opportunities for transmitting information about facial expression, posture and other nonverbal cues, it contributes to the degree of social presence [2]. In addition to the features of the medium, it is the kind of interactions and the sense of community established in the group that matter for achieving engaged communication [2]. Garrison et al. [3] claim that the effect of media is unlikely to be the most salient factor affecting the degree of social presence developed by the participants, as the feeling of social presence is influenced by "the communication context created through familiarity, skills, motivation, organizational commitment, activities, and length of time in using the media [3, p. 94]".

Asynchronous text-based environments are widely used to deliver online courses. These environments possess a range of advantages for learners who have to collaborate across time and space. However, due to the reliance on written communication, social presence can be problematic to establish [3]. Earlier research has demonstrated that text-based learning environments are not effective in supporting the development of engagement and presence in group collaboration [4]. Therefore, the moderator's role in building social presence among the participants in such environments is crucial [2, 5]. This study applies the affordance perspective for analyzing how an asynchronous text-based collaborative learning environment affects social presence. The main objective of this paper is to provide a better understanding of the online tutor's role in promoting social presence in such learning environments, thus helping the learners who have not met face-to-face engage in meaningful learning processes. The paper discusses the perceptions of students taking a distributed online collaborative learning course over one year, and seeks to answer the following questions:

1. How does lack of synchronicity in a text-based learning environment affect the feeling of social presence?
2. How can an online tutor promote the feeling of social presence among the collaborative partners in an asynchronous text-based environment?

The paper is structured as follows. First, related research on social presence is introduced and the concept of online tutoring is discussed. Afterwards, research questions, theoretical framework, context of the study, and method are formulated. Finally, the results are presented, followed by discussion and implications.

2 Related Research

2.1 Social Presence

Garrison et al. [3] recognize three interrelated kinds of presence in distributed learning environments, which are cognitive presence, social presence and teaching presence. Cognitive presence refers to the participants' ability to construct understanding by means of sustained communication. Social presence is about the participants being able to project their individual characteristics in order to present themselves as "real people". Finally, teaching presence is about the design of the course, learning activities and assessment, as well as the facilitation during the course. Teaching presence is aimed at enhancing cognitive and social presence.

Garrison et al. [3] describe social presence in terms of emotional expression, open communication, and group cohesion. Emotional expression refers to the expression of humor and self-disclosure (i.e., sharing of feelings). Open communication is characterized by reciprocal and respectful exchanges, and is realized through mutual awareness (i.e., learners addressing their comments to particular peers or referring directly to specific messages) and recognition of each other's contributions. Finally, to reach group cohesion students need to be able to perceive themselves as part of their group rather than individual contributors.

Sung and Mayer [1] suggest five broad categories of social presence:

1. *Open mind*: Students are able to express personal views freely and perceive the environment as safe.
2. *Social respect*: Students feel acknowledged, and they feel that their contribution is as important as others'.
3. *Social sharing*: Students in a group have shared values.
4. *Intimacy*: Students have a chance to learn more personal information about each other, for example, through sharing of personal experiences.
5. *Social identity*: Students feel acknowledged as individuals with their own personal characteristics.

2.2 Online Tutoring

The online tutor is a facilitator of learning who takes proactive steps in helping students build their knowledge [6], supporting content-specific cognitive activities, social activities, and meta-cognitive activities in learners [7]. Normally, online tutors do not really teach; instead, they guide students through the activities planned by the course teacher [8]. The roles of the tutor are largely categorized in four groups – pedagogical, managerial, social and technical [9].

The pedagogical role of the tutor is aimed at supporting the content-specific cognitive activities. Sometimes students taking part in computer-supported collaborative learning (CSCL) lack confidence in their progress. The online tutor is the one continuously monitoring students' progress and providing feedback to them.

The social role of the tutor, promoting the social processes in the group, can make the whole CSCL experience different for the learners. Computer-mediated communication (CMC) is often characterized as impersonal and task-oriented [10]. The online tutor can help students avoid the feeling of loneliness in an online environment [7] by building social presence and helping students feel more connected with each other [1].

The managerial and technical roles are aimed at supporting the meta-cognitive processes such as planning, coordination and regulation of the learning activities in the group. Students may be unclear about particular task requirements, and they also need the tutor's guidance regarding the use of the tools.

3 Empirical Study

3.1 Affordances

The notion of affordances is used in the paper in order to address the features of the learning environment affecting the feeling of social presence in students. Affordances are not only functional aspects of an object, but also relational. The “functional” aspect implies that affordances are enabling or constraining some activity with an object, while “relational” means that affordances of one and the same object can be different for different actors [11]. The full range of affordances a certain technology possesses may be not immediately perceived by a certain actor [11, 12].

In order to reach the best possible effectiveness, affordances of e-learning technology should be matched with the learning tasks [13]. Technological tools used for CSCL have to provide learners with opportunities to engage in a joint task and communicate effectively, share resources, engage in productive collaboration and co-construction, monitor their learning, and build groups and communities. At the same time, it is important to consider technology together with other social supports [12].

Considering affordances of a particular online collaborative learning environment is beneficial for understanding what kind of interventions undertaken by the online tutor may become critical for promoting the feeling of social presence in students.

3.2 Context

The study was carried out in the context of a CSCL course running throughout the academic year 2015–2016. The course was run by a university in Norway, where both the course teacher and online tutor (the author of the paper) were located.

The main focus of the course was design of online courses. In addition to the participants residing in (but not necessarily originating from) Norway (21 in fall and 20 in spring), ten students from two foreign universities collaborating with the host university (one student residing in and originating from Asia and nine students residing in and originating from an African country) took part.

The course teacher and online tutor met the local students face-to-face before the course start in order to provide an orientation session. Most of these students knew each other before the course started. The African students received guidance from a colleague who had completed the course before; they did not have the opportunity to meet with the course teacher and online tutor. These African students knew each other before the course started. The only student from Asia did not have guidance in relation to the course, except for the instructions provided in the course learning environment (available to all of the participants). The students from the three countries were not familiar with the foreign peers before the course.

In the 2015 fall semester, the students were randomly assigned in six multicultural groups in which they worked throughout the semester. The tasks required individual reading and group discussions. Each discussion had to be summed up and delivered to the archive by the discussion “weaver” (i.e., summarizer). The weaver schedule had to be planned by each group in the beginning of the course. Each group was also required to agree upon a “group contract”, specifying rules and commitments (a standard template was provided to them). The students were randomly re-assigned in five completely new groups in the spring semester.

In the beginning of the course, the participants were asked to upload an individual presentation (a short text with pictures) to the university learning management system (LMS), which was the main learning platform in the course.

The students had different levels of expertise regarding the use of the LMS and collaborative learning methods. The Asian student and two of the African students were earlier engaged in similar online studies and were therefore familiar with this particular LMS and collaborative learning methods in general. For the rest of the African students it was a novel experience in terms of both. Most of the students in Norway were familiar with the LMS but not with the collaborative learning setup.

3.3 Method

At the end of the fall semester a student survey was administered, using the SurveyXact platform. The survey included different types of questions (21 in total), including closed, open-ended, and Likert scale questions. The questions focused on students’ interactions with the tutor and peers, as well as the general course setup and use of the LMS. In the end of the spring semester, semi-structured interviews with the course participants were carried out. The interviews focused on the issues of social presence, as well as the challenges of managing online group work. The interviews allowed getting a deeper understanding of student reflections. Selected insights are presented in this paper. Table 1 presents demographic data of the study participants. Finally, data from the LMS provided some quantitative indicators of use.

Table 1. Demographic characteristics of the study participants

	Survey respondents (N = 14)	Interview participants (N = 9)
Origin	Norway = 6 Other = 8	Europe (incl. Norway) = 4 Africa = 5
Gender	Female = 8 Male = 6	Female = 6 Male = 3
Age	20–30 = 4 31–40 = 6 More than 40 = 4	N/A

4 Results

4.1 Course LMS and the Feeling of Social Presence

In the beginning of the course the students were asked to arrange a Skype call in their groups (without facilitation); however, not all of the students joined their group discussions. The groups’ further interactions ran asynchronously on the LMS.

The LMS offered standard functionality. The welcome page included the links to the modules of the course, course overview and the assignment structure. It also included a news section and a section where the newest contributions and uploads were displayed. The left side of the page provided access to the working areas, of which the main areas were “Discussion forum” and “Archive”. These were organized according to groups and tasks, where each group had asynchronous discussions and uploaded files in its own folders. In addition, a “virtual café” served as a common forum where students could communicate on topics not directly related to the learning activities. Learning materials could be found in the “Archive”.

Unread postings/file uploads were displayed on the front page and marked by a green exclamatory sign on the left side, helping to easily locate new contributions. In addition, there was a possibility to see who had read particular postings, which helped learners evaluate whether their message had reached other members.

The survey responses demonstrate that most students felt their written text could have been misinterpreted by their peers, and would prefer having synchronous meetings in their groups in addition (see Table 2).

Table 2. Survey questions on interactions with peers and tutor

Closed questions	Survey responses (N = 14)
Have you ever felt that your written text was misinterpreted by a peer?	Yes = 9 No = 2 I don’t know = 3
Do you think regular synchronous online meetings in your small group would be useful?	Yes = 10 No = 2 I don’t know = 2

A number of open-ended text responses indicated that some students actually switched to alternative communication tools (“S” stands for “survey” and “I” for “interview” in the further text. The survey was carried out anonymously, thus S1 and I1 may or may not be the same student):

- **S4**: […] the discussion forum in [LMS] is not a good tool, hard to communicate when you want to. My group had to use another application to communicate.
- **S9**: All the folders and sub folders made it difficult to engage more often using mobile devices in discussion forums.

The interviews helped reveal that for some students building informal environments was important for gaining confidence in what they were going to post on the LMS:

- **I4**: When you are limited to only formal conversation channels you are kind of careful, what you are saying, what they will think about you – but after brainstorming out here in the informal group it kind of gives confidence on what you can say.

Six of the interviewees reflected that the asynchronous mode of interaction sometimes led to more scattered contributions and stating individual opinions rather than integration of ideas. Waiting for peers' replies was a challenge:

– **I3**: Someone would just come and throw in, and disappear. And some of the posts would particularly show that this person did not even take time to read through the previous posts before putting it there. It felt more… everybody was interested in just putting the post to clear the task, to show their presence, that "I was there".

4.2 Online Tutor Promoting the Feeling of Social Presence

The online tutor was monitoring group discussions on a daily basis, addressing student inquires, motivating students to contribute, acknowledging individual and group contributions, and reminding of deadlines. Sometimes the tutor asked guiding questions to help students develop their discussion and provided additional learning materials. The tutor also posted comments on students' deliverables (after each task in the first part of the course and after each module in the second part). Being aware of differences in the students' schedules, and in order to minimize their coordination efforts, the online tutor kept emphasizing the students' responsibility for notifying their group about possible absence or delayed feedback.

Based on the framework of five categories of social presence from Sung and Mayer [1], ten Likert scale statements were presented to the students in the survey, for example: "Postings made by me and others in the course room were treated as equally important by the tutor", "The atmosphere in my group was open for me to express my opinions", and "I learned about my peers and tutor through their sharing of personal experiences and emotions". The students had to evaluate the items from 1 (strongly disagree) to 7 (strongly agree). The results are presented in Table 3. Students were also provided with an optional comment box in case they wanted to reflect on the statements they strongly agreed or disagreed with.

Table 3. The feeling of social presence perceived by the students

Category	Number of items	Mean
Open mind	1	6, 3
Social respect	4	6
Social sharing	1	5, 6
Intimacy	2	5, 1
Social identity	3	4, 9

Open Mind. The results demonstrated that students perceived the environment as safe, and could share their thoughts and opinions freely. This is supported by their open text responses:

- **S12**: At no one time did I feel scared of giving in my contribution. There was no harshness in the group and the tutor. Actually, there was encouragement from both the group and the tutor on giving our opinions during the discussions.
- **S14**: I felt that my views were never ridiculed at any time, so it made me free to say whatever I wanted to say.

Social Respect. The students were also generally positive regarding the aspect of social respect, supported by a number of open text responses:

- **S9**: All discussions have been respectful and constructive.
- **S11**: I sincerely enjoyed the discussions because we respected each other and we never had conflicts or misunderstandings. The tutor also respected our views and treated us equally.

At the same time, three students indicated uncertainty, claiming that they do not really know if the tutor acknowledged their contributions, which may indicate a need for more active and explicit tutor support.

Generally positive reflections were provided in the interview discussions, with one student even reflecting that they were not happy to change the group in the second semester. However, two of the interviews revealed additional and somewhat different insights. One of the students was reflecting on how cultural background may influence the discussions and consideration of individual arguments:

- **I2**: From my background, even if somebody's argument is not good enough, you kind of appreciate it […], which is different from their side – if it's not good – it is not good! […] But I understood that could be cultural.

Another student reflected that she was unsure about how to react when her argument was not included in the final deliverable:

- **I4**: […] when someone is weaving and you realize your contribution is not there […]. Without a tutor coming in, you don't know whether you make sense […]. When a tutor comes in, it's motivating and it feels you have made sense.

These insights are valuable for understanding the learning situations where tutor involvement may be critical for preventing dysfunctional phenomena in the group.

Social Sharing. Both in the survey responses and interviews the students underlined the importance of the group contract. The contract helped them build a shared understanding of the process and responsibilities in the group.

Three of the interviewees commented that sharing their personal introduction in the beginning of the course felt more of an assigned task rather than learning about their peers, reflecting that they only read a few introductions uploaded by other members.

Intimacy. Student insights suggest that the environment could have been perceived as providing little opportunity to learn about each other:

- **S11**: The sharing on the LMS and my group interactions were strictly on the academic discussions we were meant to handle. There was very little sharing of personal experiences and it was too little for me to learn about my peers or my tutor!

Social Identity. Finally, the student responses suggest that the environment could have been perceived as rather impersonal. While the categories of intimacy and social identity scored lowest, it is important to note that not all of the students actually wanted to engage in more off-task interactions. When asked about that in the survey, three students expressed a clear "no", emphasizing that they joined the course to learn, not to socialize. Four students were unsure, mainly due to the time constraints. However, seven were claiming that they would like such opportunities, for example, in order to build trust in the group, or create networks for future collaboration.

It was mentioned by two interviewees that they liked to have the virtual café available in the LMS, even though they did not engage in conversations that often:

- **I2**: […] I think it is a good avenue even to kind of relieve yourself from the steam and stress of the task, and go and talk about other things.

The café was exploited rather actively in the first part of the course (254 postings in total) but stayed relatively inactive in the spring semester (18 postings). The course teacher and online tutor also participated in the virtual café.

4.3 Teaching Presence

Both in the survey and the interview discussions most students reflected that one of the most crucial aspects was the subject matter feedback they got from the tutor. Even though this aspect is not directly related to the main focus of the paper, it is important to bring up in this discussion as teaching presence has an impact on cognitive and social presence [3]. The main challenge for the tutor is to identify how much involvement is needed in case of particular groups. In the survey, students were asked how often they would like the tutor to post in their discussions. Their answers varied greatly:

- **S10**: Not so often, but once in a while; frequent monitoring also tires – we are self-directed.
- **S3**: From time to time, so we know tutor is there somewhere.
- **S13**: As often as it can be possible, because it encourages the learners in knowing that their work is being looked at by the tutor.

Some of the students wrote that the tutor's guidance is necessary only when the group does not seem to manage themselves, for example if there is an emerging conflict situation, if people are going astray, or if some group members do not participate.

Although the amount of desired tutor involvement is dependent on individual learners, it seems to be important for all of the students to know that their tutor is "there", following the discussions.

5 Discussion

Table 4 provides an overview of key LMS affordances potentially affecting students' feeling of social presence in this asynchronous learning environment. It is further discussed how the asynchronous mode of interaction may constrain the development of social presence, and what the online tutor can do to address this issue.

Table 4. Affordances of the LMS affecting the feeling of social presence

Affordance	Features of the LMS	Enables learners to
Communication	Threaded forum discussions New postings are marked New postings are displayed on the front page Emoticons and text editing options Private messaging on the LMS	Communicate asynchronously Organize discussion threads thematically Respond to particular contributions Spot newest postings in the forum and front page Emphasize emotions graphically Communicate with individual members
Resource sharing	Shared repository New uploads are marked New uploads are displayed on the front page	Upload and download resources Spot newest contributions in the archive and front page
Co-construction	Shared discussion forum Collaborative text editor	Sustain joint attention and reflect Build on each other's contributions Engage in co-writing
Monitoring	"Read by" feature on postings	Monitor whether the message had reached the peers
Individual presentation	Individual contact cards (contact information & photo)	Present oneself and learn about peers

On one hand, the asynchronous mode of communication ensures flexibility [12] for students from different parts of the world to participate. Asynchronous discussions make learning visible and help students reflect [3, 14, 15]. Moreover, in earlier studies students were found to enjoy asynchronous brainstorming as they could share their opinions without being interrupted or judged [14]. Therefore, the possibility to communicate asynchronously may contribute to such facets of social presence as open mind and social respect, as students may express their perspectives, as well as acknowledge and respond to their peers' contributions in the discussion forum.

At the same time, lack of synchronicity in the environment may create challenges for facilitating open mind and social respect. Due to the temporal disconnectedness, the feeling of social presence in asynchronous communication is often based on participants' expectations regarding when their peers check the communication channels [16], and the "normal" flow of interactions is violated due to delayed feedback [17]. This may cause mismatches in the communication process, and some of the contributions may be left out. The results of this study demonstrate that the asynchronous mode of communication sometimes resulted in more scattered contributions rather than integration of ideas. Moreover, students often felt that their text could have been misinterpreted by their peers, and some of them chose to switch to alternative communication channels. The students' responses demonstrated that introducing the online tutor in such a learning environment is beneficial. The learning environment was generally perceived as open and respectful, as students felt encouraged to share their opinions freely. The interviews provided evidence that the tutor's role can be crucial in preventing dysfunctional phenomena and supporting a respectful atmosphere in the group. The tutor has the authority to draw students' attention to individual contributions that were not considered, and in this way promote the feeling of mutual acknowledgement.

Initial personal introductions are crucial for creating common ground and establishing shared values among course participants. Lack of information about the peers' knowledge is critical in CSCL since learning is realized by means of co-construction of knowledge [18]. Students were earlier found to emphasize that group performance could be increased if it was possible to directly explore their peers' competence [19]. The results of this paper suggest that the text-based introductions in the beginning of the course were not particularly effective. At the same time, the group contract helped learners agree on the shared values and responsibilities they were carrying with them throughout the course.

Finally, as getting acquainted with peers is important for building good relationships, it is important to create sociable collaborative learning environments [10] which would facilitate such aspects of social presence as social identity and intimacy. It is important to provide a place for students to engage in off-task interactions when and if they want to. The virtual café was acknowledged in the interviews as a place available for off-task communication, even though not actively exploited in the second semester. The results of the study suggest that the course environment as a whole was perceived as somewhat impersonal, providing little opportunity for students to learn about each other. Unlike asynchronous communication channels, synchronous tools may support social presence and off-task interactions [15].

The importance of subject matter feedback from the online tutor was emphasized by most of the students. Students appreciated the tutor continuously monitoring their progress and bringing them back on track if necessary. However, students had different expectations regarding the frequency of interventions. Finding a good balance between support, learning and fading remains one of the challenges in CSCL research [12]. Tutor interventions that lack precision tend to interfere with ongoing thinking processes and negatively affect the collaborative learning process [20]. A student directly addressing the tutor in an online learning environment may also make other students think their response is not needed [21].

Therefore, complementing asynchronous text-based learning platforms with synchronous sessions facilitated by the online tutor can address several crucial aspects. First, synchronous communication especially in the beginning of the CSCL process will help learners introduce themselves and learn about each other's areas of expertise. This would facilitate building common ground and establishing shared values in the group. Further synchronous "checkpoints" throughout the course could be the place for the tutor to provide instant feedback and ensure the groups and the individual students are on the right track in their learning progress. Increased levels of teaching presence would have a positive effect on cognitive and social presence. Finally, additional synchronous communication can also promote more social off-task interactions among the learners and the tutor.

6 Implications

In their work, Sung and Mayer [1] suggest specific implications for fostering the feeling of social presence. They argue that the moderator should promote mutual acknowledgement and respect. Learners must know that it is worthwhile to contribute and their time is valued by other participants. The moderator has to be open-minded and learners must know that they can share their views freely. The moderator should be able to share some personal and professional information and facilitate the students to do the same. Careful use of humor and addressing individual students by name are other examples of good practice aimed at facilitation of the personal connection. The results of this study can complement the list with the following implications:

1. *Group contract*: The participants should agree on the group contract before starting the collaborative learning process. This contract will specify responsibilities and expected behavior in the group. Students should be provided with a copy of the contract. Discussing the social contract is important for establishing shared values.
2. *Equality of contributions*: It is important to bring the groups' attention to individual contributions which were not taken up. While some contributions may be skipped by peers without providing a reason explicitly, the author of the contribution may decide to decrease his/her further participation in the discussion. Individual learners must feel their contribution is acknowledged by the rest of the group.
3. *Promoting awareness*: It is important to remind the students that they must notify their peers of possible absence. To avoid extra coordination efforts and anxiety in the group, they should state clearly when their contribution can be expected. This facilitates respectful communication among the group members.
4. *Coordination*: The online tutor may help learners coordinate their activities by reminding of upcoming deadlines. Sometimes it may be necessary to contact absent individual students by email. They may be having difficulties navigating in the environment, or withdrawing from the discussion due to misunderstanding or lack of acknowledgement from the rest of the group.
5. *Off-task communication*: A place within the main learning platform should be provided where learners can communicate on off-task issues if they want to. The online tutor's involvement here would help learners feel connected.

It may be beneficial to complement the asynchronous learning environment with synchronous communication tools in order to increase levels of social (as well as teaching and cognitive) presence. Video channels were also earlier found to increase the degree of social presence perceived by the group members in zero-history groups [22].

6. *Initial video-conference*: A video-conference facilitated by the tutor in the beginning of the course is recommended, for the participants to introduce each other's personal background and discuss their areas of expertise. This will help learners build common ground and establish shared values.
7. *Progress checkpoint meetings*: The tutor should provide instant feedback in regular synchronous group meetings, increasing the level of teaching presence. Moreover, additional synchronous communication in groups is likely to promote more social off-task interactions.

7 Concluding Remarks and Future Research

Social presence distinguishes a collaborative community from simple exchange of information. As Garrison et al. [3, p. 96] note, the tone of the messages in a collaborative community should be "questioning but engaging, expressive but responsive, skeptical but respectful, and challenging but supportive". The analysis in this paper has demonstrated that the asynchronous mode of interaction in the online learning environment may affect the development of social presence negatively. Namely, asynchronous communication sometimes led to scattered contributions, and some of the contributions remained left out. Most of the students felt their text could have been misinterpreted by other members. Moreover, the opportunities to build common ground and learn more about peers were rather limited. The paper has discussed how the online tutor can contribute to learners' feeling of social presence and mutual respect in such asynchronous text-based learning environments, possibly complementing the environment with synchronous communication channels.

CSCL courses often involve an international audience, as for the course discussed in this paper. People from different cultures consider different behaviors to be critical for common task completion [23], and culturally diverse groups may have different perceptions of CSCL [14]. Interestingly, there is evidence that reduced levels of social presence in CMC environments actually helped the learners reduce anxiety in multicultural groups [24]. More research is needed in this direction as currently little is known regarding the support for multicultural CSCL groups [25].

Moreover, the learning activities of the course described in this study were not supported by collaboration scripts. Better understanding is needed regarding the potential of collaboration scripts in helping CSCL participants reach increased levels of social presence in online learning environments.

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3D Real-Time Collaborative Environment to Learn Teamwork and Non-technical Skills in the Operating Room

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Abstract. Risk-management training in the operating room (OR) can be achieved by involving learners in a simulated risky situation. The task is particularly complex because most of the time, the causes of an accident or an adverse event imply a large variety of contributing factors that are (i) difficult to combine artificially and (ii) even harder to detect and evaluate in a dynamic training context. This paper describes a model for specifying pedagogical objectives that has been integrated and used in a 3D virtual operating room project designed to train medical staff on risk management, particularly risks linked to communication default. Training sessions organized with trainers, student-anesthetist-nurses, student-operating-nurse and student-anesthetists show how teamwork efficiency in critical situations may be evaluated in a collaborative environment.

Keywords: Educational objectives model · Design collaborative achievement · Collaborative virtual environment · Learning game · Risk management · Healthcare training

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1 Introduction

1.1 Awareness of Healthcare Quality

In healthcare, 54% of surgical adverse events occurring in industrialized countries are considered as avoidable events [11]. The operating room represents the highest risk for the patient, as 65% of adverse events in healthcare are related to surgery [33]. It is a complex environment [9]: (i) different disciplines, expertise and cultures coexist within the team (ii) the operators cooperate for patient care and deal with unanticipated events, (iii) the operator's interactions are non linear and often unpredictable, (iv) humans interact with each others and with technical objects or computerised systems which deliver technical information, (v) the state of the system changes and evolves over time. A dozen of dimensions of complexity in health care are described by Carayon [7], Plesk and Greenhald [28] and Effken [9]. The composition of the team is heterogeneous and each team member has their own technical skills and responsibilities. There are multiple interactions that influence the evolution of the system but a successful operation depends on what information is dynamically exchanged [27] to understand what is going on. Different reports note that; most of the time, a communication default is the root cause or contributing factor to an adverse event [13,16,18,22,26]. Wrong surgery site (WSS), wrong patient events or wrong procedure are often reported [5,31] although they appear in 1.7 to 3.6 events out of 100,000 operations [31]. In 2009, the World Alliance of Patient Safety project, launched in 2004 by the World Health Organization (WHO), published a list of recommendations and security checklists to prevent adverse events in operating theaters during surgical procedures [32]. More recent studies shows how errors result from misinformation (e.g., incorrect information obtained from other departments) and misperception (e.g. from right-left confusion when interpreting imaging results [3]). The median prevalence estimate for wrong site surgery was 0.09 events per 10,000 surgical procedures [3]. The WHO checklist displays 3 columns that represent the three phases of surgery: (i) from the patient's arrival to the induction of anesthesia, (ii) from patient's induction to skin incision and (iii) from skin incision until the end of the operation. Studying complex systems, Reason [30] shows that most of the time, accidents result from multiple successive failures which could not have been corrected or stopped in time. The WHO checklist aims to build different barriers to prevent certain types of errors that tend to be committed in each of these three stages [4]. Haynes et al. [14] showed that the use of the checklist significantly lowers surgical morbidity and mortality.

The recommendation imposes to identify a coordinator who is responsible to manage the safety procedure. In practice, the role of checklist manager can be attributed to anyone. It depends on clinical services and hospitals. The role of the checklist manager consists in checking information from different sources, on different topics and making cross-control. In case of doubt, they can stop the surgery process or ask for help. Fudickar et al. [2] show the effect of the WHO Surgical Checklist on communication. "The checklist should be understood not merely as a list of items to be checked off, but as an instrument for the improvement of communication, teamwork, and safety culture in the operating room, and it should be implemented accordingly". Yet, very few specific courses exist to help professionals and students to learn risk management and non-technical skills. In many hospitals worldwide, simulation centers have been created for healthcare education. In most cases, they replicate different medical places as the operating room or the patients room. They focus mainly on technical skills and aim at reducing the gap between what students learn in textbooks and gestures they are expected to use in the real professional world.

The next section describes the learning game 3D Virtual Operating Room, which has been designed to train inter-professional teams to the specific context of the operating theater.

1.2 3D Virtual Operating Room

3D Virtual Operating Room [21] (3DVOR) is a representation of the operating theater under the shape of a collaborative virtual environment. 3DVOR is a real-time multiplayer virtual environment dedicated to train and prevent risk management inside the operating room. It is focused mainly on near-miss or standard situations that can be failed due to communication defaults. 3DVOR offers collaborative training for all operating theater professionals including anesthetists, surgeons, nurses and health managers. This research has been initiated by the scientific interest group named Serious Game Research Network and the University Hospital of Toulouse (France).

The universe of the virtual operating room is composed of avatars which represents medical staff, nurse staff, a patient and technical equipment: anesthesia machine, electric generator for the scalpel, surgical aspiration system, etc.

This environment was specifically designed to be used in a learning context. It provides features dedicated for the trainer for them to follow in real time what is going on within the virtual operating room and interfere with students strategies.

It was designed as a combination of standard game design mechanics and an innovative system of interaction metaphors to reproduce teamwork. Each student plays a different role to compose a virtual medical team. Any player can see on the game screen what he is doing and what the other team members are doing, for example controlling arterial blood pressure, placing a catheter, injecting a drug, etc. The details of the model enabling the real-time collaboration of several players within the game is described in [25].

Graphical interactions allow each player to collect, memorize, listen and broadcast information [29]. They can also ask questions and give answers thanks to information tags stored in their virtual memory. A voting system is available to debate and vote on predefined topics.

The virtual universe is represented by a set of objects as technical equipments, documents and avatars. In a point and click fashion, each player moves in a 3D scene, displays different menus of actions and selects the action he wants to do on a specific object. Each action is associated with an object in to universe. Some action reveal information that is automatically collected and stored within the player's virtual memory. According to what is done or known by the players, the state of the environment is changing dynamically. The application monitors every actions, communication, discussion and decision making that the team is doing. In such digital virtual environment, the player seems to be free to act and communicate with their teammates. A large variety of possibilities can be explored and many paths can lead to different levels of success or to different failures. But actions are gradually unlocked as the player accomplishes tasks in the game. And some indicators are displayed to inform the team on their current grade.

Educational situations are designed to train the team to anticipate failures, identify, reduce or correct mistakes, evaluate the root causes, consider the situation and take appropriate actions. Among this educational situations, some of them focus on a particular topic: the use of the Surgical Safety Checklist.

2 Purpose and Goal

This article describes a model to design individual's goals and team's goals in a virtual collaborative environment. The embedded pedagogical content targets risk management education within the operating room. It is based on real adverse events where a communication default was identified as a contributing factor. As learning is a process which is constantly modified by experience [19], involving a team of learners in a virtual near-miss context to observe teamwork, professional and informational behaviors should bring real benefits. At the end, as the educational content is fully mastered by the trainer and entirely controlled by the game engine, it is supposed to identify the mistakes and evaluate the miscellaneous causes of a near-miss. Learners being confronted with a professional unpredictable situation in which they have been wronged are likely to be aware of the consequences of their actions. It should help to learn non-technical skills as leadership, situation awareness and decision making.

This paper presents how the educational objectives were designed and proposes to check if the students succeed to manage first a professional standardized situation an then an unpredictable situation. We study how each learner interacts with their virtual partners and whether they as a team find a way to reduce the risks in this unpredictable educational situation. The present study will focus on how an semi-automatic debriefing can be produced both for learners and their trainer based on a virtual adverse event within the scope of training in the management and prevention of surgical risks.

3 State of the Art

3.1 Virtual Environments for Learning

Learning environments are designed to support learning as the construction of knowledge in learners. Learning takes place by changing the settings of the simulated environment and observing the consequences of actions performed by the student. Simulation is now increasingly used in many domains (scientific, medical, marketing, etc.). Many benefits are highlighted in the literature; we can mention here the simplification of reality to facilitate understanding. For De Jong [17], the reasons for the learning attraction of simulation are increased motivation, better understanding of the phenomena, greater ability to adapt to similar problems in other contexts. McGaghie et al. [24] list thanks to a systematic review 12 features and best practices of simulation based learning in medical education. Among them, feedback, curriculum integration, outcome measurement, skill acquisition and maintenance are mentioned. Compliance with Mc Gaghie et al. practices leads us to define a model educational design in a virtual environment for evaluate a set of cognitive and behavioral objectives.

3.2 Multiple Users in Real Time

In a virtual environment, each users is represented by an avatar and, in addition to figuring where he is, each player needs to understand where are the others and what they are actually doing. Many features of a 3D scene participate to better comprehending the actions and states of mind of other users: graphical representation of the avatar's actions, player's natural speech, maps of the virtual scene, player's chat conversation, avatar's presence, gestures, or facial and body animation, emotions modelling. Capin et al. [6] list crucial functions in addition to those of single-user virtual environments:(i) perception (to see if anyone is around) (ii) localization (to see the others) (iii) identification (to recognize who i am), (iv) visualization of others' interest focus.

To allow users having coherent dialogues, main features must be provided and they have to respect implicit conversation rules. To be coherent, conversation generally follows implicit rules as choice of a common conversation topic, choice of the listeners and turn-talking rules. In 1970's, Grice [12] argued that people in conversation must be cooperative. Speakers must try to "make their contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which they are engaged". Pons-Lelardeux et al. list main functions to represent dialogue and decision making in a multi-player environment. Their communication system proposes several features to allow several player's conversing and making decision. Their system is based on the implicit rules of real conversation: (i) perception (to memorize the current contextual information) (ii) identification of the speaker (iii) topic of the conversation (iv)everyone's opinion (v)visualization of the final leader's decision.

3.3 Educational Design in a Virtual Environment

Allowing for joint activity in a virtual environment is not a sufficient condition for experiential learning to happen. Instructional design is the science of designing pedagogical experiences (in a virtual environment in this context) where the activity of one or several users is planned, observed and evaluated against a set of objectives defined beforehand. IMS-LD is a well-known educational modeling language [20] for designing such experiences. It is based on the metaphor of a play where roles and acts are related to users and pedagogical scenarios. It is closed to the UML modelling language universally in use in computer science. Maroto [23] has developed a module for deploying and executing a IMS-LD scenario onto the virtual environment Open Wonderland.

Learner tracking is another necessary step for controlling the experience of the user. Intelligent tutoring system (ITS) is the term used for describing a system where the actions and interactions of each user are collected for dynamically adjusting the experience or for further analysis (debriefing). Usually, an ITS is composed of many modules communicating with each other and dedicated to one function: activity module, error module, learner module, pedagogical module, etc. Eventually it takes the form of a virtual tutor embedded in the environment (like STEVE the pedagogical agent [15]) or remains invisible to the users, like an informed environment.

Finally, the evaluation takes place on the basis of the activity tracked online. The challenge, known as task tracking or plan recognition [8,10], consists in reconstructing the meaning of the task from the low-level activity of the users so as to enable comparison with expected behaviours modelled in the scenarios. The desired outcome of this process is not only to ensure that the scenario has been traversed by the learners as expected, but also to point out the errors and misconducts along the way. Explicability is the most important criteria of the whole process, as the main leverage for learners to actually acknowledge their errors and thus facilitate the learning.

4 A Model to Design Collaborative Educational Objectives Including Communication and Action

Szyld and Rudolph [1] define debriefing in healthcare simulation as "the learning conversation that follows a simulation session. The instructors role in providing feedback and guiding reflection is critical to ensure that reflecting on the simulation experience yields learning and growth in accordance with the stated educational goals of the session". Therefore, the trainer needs to see some cues to show an effective debriefing. The tutoring system presented here should help the trainees to understand their errors and the trainer to build the debriefing irrespective of their experience. The model described in Sect. 4 is used to present an automatic result of success or failure to the students at the end of the training session.

4.1 Different Kinds of Objectives

In real life or in training context, understanding how an adverse event has happened is crucial to improve behavior facing to a standardized or an unpredictable situation. To help practitioners and get them to commit to a rigorous approach, the National Authority for Health (HAS) recommends the ALARM (Association of Litigation And Risk Management) systemic analysis method. It proposes a systemic approach to complex systems, which includes 5 stages: (i) data collection, (ii) reconstituting the chronology of the event, (iii) identifying shortcomings in care (defined in relation to standards for good practices), (iv) identifying their causes (contributory and/or influential factors) and (v) proposing measures for improvement. Our model uses the ALARM method to collect, store and identify causes of success or failure, in order to display some recommendation to improve the team's performance.

At the beginning of a game session, a briefing is displayed to inform the team on the patient's pathology and the scenario's expectations. The main objectives mentioned at the briefing present a general context but the specific risks the team has to managed are not mentioned. Therefore, some educational objectives are displayed and others are hidden in order not to affect the behavior of the trainees.

On one hand, in order to assess the performance of the students, the model embeds a set of metrics to measure how well the standard procedures are applied and how the team of students reacts when they are facing to an unpredictable situation. On the other hand, others objectives are used to divide the scenario into small steps and inform the students on their progress during the game session. As a result, different types of objectives compose a game scenario:

- step objectives to inform on the level of progression in the scenario [visible]
- educational objectives that are not visible to the trainees but are monitored by the game [invisible]. There are two sub-types of these:
  - objectives of success (expected outcomes) to inform on what was correct to reduce risks
  - objectives of cause of failure (predictable failures) to inform on what increased a particular risk

Educational objectives have to be designed as part of the scenario and must be checked in real time by the game. This allows to provide an automatized and personalized debriefing based on the activity during the game session. But the application needs to be able to understand what is the objective and how it can be evaluated. Most of the time, applications are not able to evaluate events which can not be listened by the game. So, all the macro-objectives have to be composed of micro elements that can be listened and captured on the GUI. Then, all the micro elements need to be associated with a particular grammar to construct macro-objectives.

Unit elements (Table 1) are events that can be observed and automatically captured by the game during the game session. Unit elements are actions, information acquisition or transmission, discussion and decision making. They can be considered as micro-objectives and therefore they must be associated in order to construct more meaningful game objectives.

Complex objective are constructed by the tree-like association of unit elements. Operator nodes are introduced in the pedagogical description grammar

Table 1. Element types necessary for defining an objective

Element type	Example(s)
Action	Someone makes a contextual action
	A team member writes something on a document
Communication	Someone sends a piece of information to someone else
	Someone collects a piece of information 'anomaly'
	The team initiates a collaborative discussion
	Someone argues a relevant argument
	Someone asks a question to another member
Inspection	Someone reads an information on a document
Decision	The team makes a decision on a topic

in order to do so. Table 2 lists the available operators. Owing to the tree-like recursive description model, the expressiveness is potentially unlimited, although in practice only a few layers are necessary for a complex objective to be defined (see Fig. 1). The ORDER operator allows designers to define an objective with a set of basic elements that should to be done in a specific order. For example, to test 'infectious outcome', the application needs to know if the player first washes their hands, then puts their gloves and injects drugs. If the user first injects drugs then puts their gloves, the infectious risk is very high. So the application needs to store the chronology of what happened. The order between actions and communication is also important especially for the surgical security checklist. Before ticking the checklist to confirm the patient's identity, the checklist leader has to collect all the information about the patient's identity from all the team members. The operators help designer to combine different objectives to build new complex objective.

Table 2. A grammar to combine objectives

Operator	Expression
OR	At least one sub-objective must be fulfilled
AND	All the sub-objectives must be fulfilled
NOT	The opposite of the objective has to be fulfilled
AT LEAST	At least x objectives among the sub-objectives must be fulfilled
ORDER	All the sub-objectives must be fulfilled, and in a specific order

The same model is used for representing the expected outcomes of the game as well as the unexpected, yet predictable, errors. For example, the checklist manager ticks the box to confirm the patient's identity whereas they did not make a cross-control of information on patient's identity. They have to check from the patient their identity and check on patient record if the same identity is present on any document. The main regular error consists in confirming the patient's identity without any cross-control. Therefore, the same actions can be bound to a success objective as well as a failure. The success objective consists in (i) reading or collecting patient's identity information from the others on any documents in the medical record, (ii) discussing and making a decision to confirm the patient's identity and then (iii) ticking the box on the checklist to confirm the patient's identity. Ticking the same checkbox without any prior cross-control or collaborative discussion is considered as a failure in the procedure and therefore a failure objective.

All the objectives for a scenario (success, failure and level of progression) are likely to be presented in a large variety of tree-like structures where nodes represent objectives and leafs represent expected action, communication and decision. At the beginning, the application initializes all objectives with a Boolean value "false". While students interact with the virtual scene, the engine listens every events and checks if some objectives are fulfilled either by the individuals or by the team. When an objective is reached, the engine converts the value of the objective to "true". Step by step, objectives are reached or not and the risks may increase until the training session is stopped. At the end of the training session, the application is able to display the main outcomes.

This primary objective overlaps with educational objectives linked to the current damaged situation. The schema in Fig. 1 examplifies an educational macro-objective that combines different expected unit elements associated with operators.

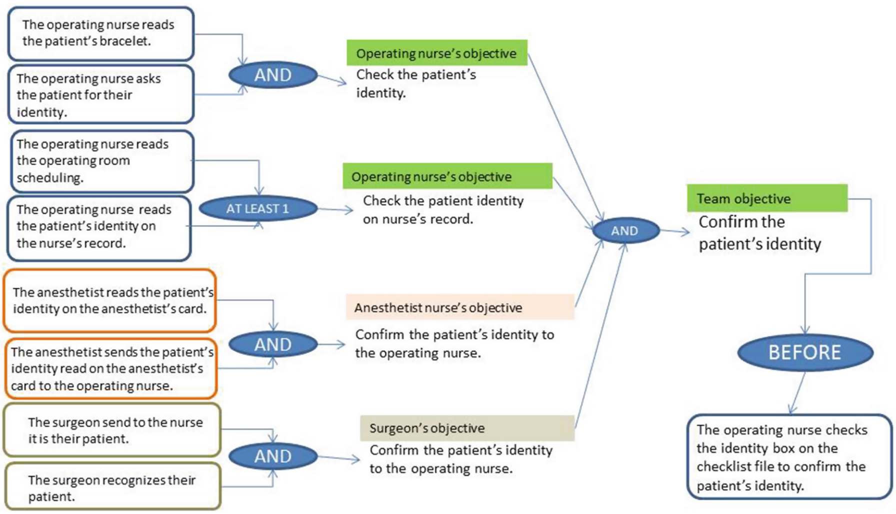

Fig. 1. The educational objectives can be represented in a tree-like structure where nodes represent objectives and leafs represent action or communication.

5 Experiment

5.1 Context

This environment was experimented at the University Hospital of Toulouse with the participation of last-year undergraduate students from the Anesthetist Nurse School of Toulouse and the Operating Nurse School of Toulouse. The experiment was separated in two steps. The first part of the experiment was dedicated to familiarize the students to the virtual environment. The second part of the experiment consisted in confronting them with an unpredictable situation.

8 teams composed of 3 students were involved in these experimental training sessions. Each student plays their role as a professional in the virtual operating room. All the students had already worked in a real operating room during a professional internship. Like any medical simulation, the experiment included a succession of three stages: (i) a briefing, during which was explained how the session would be run together with an introduction to the training objectives; (ii) the activity itself (or game stage) during which the participants played out the scenario specially designed to work to the teaching objectives relating to the established curriculum; and (iii) the debriefing.

5.2 Experimental Protocol

The experimental protocol included 4 steps: Firstly, the teacher made a briefing on the virtual environment and its main features and explained how to play the game. Natural conversation between learners was banned during the game. Everyone have to use the communication system provided by the virtual environment to exchange opinions and information. Secondly, the learners tried to familiarize themselves with the virtual environment, particularly how to talk to the patient, how to move to the computer which displays the MRI, how to discuss with the other teammates, etc. They used first a scenario presenting a standardized situation without any difficulties nor traps. Two students composed the first team in the standardized situation while the third one played the same scenario in parallel with a virtual non-playing character. At the end of this step, a debriefing was brought to recap the different features and their usage. Thirdly, the team of 3 students tried to manage a new professional situation presenting some irregularities. Fourthly, at the end of the session, an automatized and personalized debriefing was produced to support the trainer and provide feedback to students on what risks were mastered and what should have been done to reduce risks. During all training sessions, computer data, video of training sessions were recorded.

5.3 Two Training Situations

Two training situations have been designed for this experiment to train people on the patient security checklist which is supposed to be used to prevent wrong patient error and wrong site surgery. The educational context is based on the first phase of a surgery, that is the first column of the checklist: from the patient's arrival to the induction of anesthesia. The three first checklist's items are concerned, listed in Table 3.

Table 3. The first 3 questions of the patient safety checklist.

Question	Admissible answers
Is the patient's identity confirmed?	Yes, No, Not applicable
Is the patient's operating site confirmed?	Yes, No, Not applicable
Has the patient/family confirmed his/her consent?	Yes, No, Not applicable

The first situation is based on a standardized professional situation and the second one is a non standardized situation that contains multiple anomalies. Both present a patient who has a cerebral tumor. Depending on the size of the tumor, the patient is supposed to be able to talk or not. Students are expected to identify the anomalies, exchange on them, take appropriate decisions before they fill the checklist's items and move the patient to the operating room. The second educational context imposes to adapt the security rules when the team is facing to non-standardized situation (i.e.: with an unpredictable anomaly). For example: the patient cannot state his name, information is missing on the medical record, etc.

The scenarios are both divided into 3 steps:

1. Verifying patient's identity
2. Verifying patient's operating site
3. Move the patient to the operating theater

And the 3 main educational objectives are: (i) Reducing the risk of patient's identity error applying the security checklist (ii) Reducing the risk of patient's wrong site applying the security checklist (iii) Adapt the procedure to a specific and near-miss context if they identify some anomalies.

6 Results

The question of debriefing in the context of an operating theater is a delicate one as it relates to the complexity of the system. Indeed, teamwork in the operating room cannot be summarized as the straightforward coexistence between technically competent individuals. The operating theater can be considered to be a complex system since it functions in a dynamic and uncertain environment, with the professionals concerned maintaining among themselves relations that can be both hierarchical and complementary around a shared goal of dispensing optimum care for the person being operated on. Each surgical team and each of its members have specific skills and knowledge. The system of objectives presented here tries to take into account both each member's capabilities in carrying out their tasks and the ability of the team to ensure precise co-ordination.

Table 4. Synthesis of reached step objectives

Objective ▽ Scenario ▷	Standardized	Near-miss
Check the patient's identity	6	6
Check the operating site	5	5
Move the patient to the operating room	7	0

6.1 Step Objectives

Among the 20 training sessions, 10 sessions focused on the same standardized situation and 10 sessions focused on the same near-miss situation. Each training session lasted in average 2 h, during which 1 h was actually spent playing the game. Among all the training sessions, most teams succeeded to reach the step objective "Move the patient to the operating theater" in the standardized situation whereas they failed to managed the near-miss situation (see Table 4).

6.2 Educational Objectives

The first objective consists in evaluating if the teams managed to reduce the wrong patient error risk applying the checklist. The second one consists in evaluating if the teams managed to reduce the wrong site risk applying the checklist. Tables 5 and 6 show the number of times the team completed the main objectives.

Even though most of the time teams failed to reduce the wrong site risk applying the checklist, just under half of the teams checked little more than half the micro-objectives (see Table 7).

The most common error made by the teams playing to the near-miss situation focused on the item "Is the patient's operating site confirmed?". Most of the time, this item has not been checked. Table 8 lists the main errors stored by the system.

Table 5. Educational objective: "Avoid the patient's identity error risk" - Number of times the teams succeeded

Objective ▽ Scenario ▷	Standardized	Near-miss
Avoid the wrong patient error risk applying the checklist	0	2
Confirm the patient's identity on the checklist	5	3
Adapt the security procedure to the context	NA	4

Table 6. Educational objective "Avoid the wrong site error risk" - Number of times the teams succeeded

Objective ▽ Scenario ▷	Standardized	Near-miss
Avoid the wrong site error risk applying the checklist	3	1
Confirm the site on the checklist	4	2
Apply the standard procedure and fulfill the checklist	4	3

Table 7. Success rate for the objective “Avoid the wrong site risk”. Half of the teams were not able to complete any objective whereas other teams managed to complete partially (or entirely) the game objectives.

Team number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Success rate (%)	0	0	75	0	33.3	100	100	60	100	50	100	60	0	83.3

Table 8. Frequency of failures for the educational objective “Avoid the wrong site risk”.

Type of failure	Count
The item “Is the patient’s operating site confirmed?” was not checked	8
The operating nurse had not checked the operating site on the MRI	4
The surgeon has not confirmed the operating site to the checklist manager	3
Nobody sent to the checklist manager the surgery and the operating site told from the patient	2

Among the teams that were able to fulfill a part of the objective “avoid the wrong site surgery risk”, 4 teams succeeded with the following activities: (i) the surgeon player had examined the patient’s motor function and the patient’s communication ability to identify the operating site, and (ii) the surgeon player had checked the surgery site on the MRI. Yet, only one surgeon player has sent the crucial information to the checklist manager.

7 Conclusion

The collaborative virtual environment featured in 3DVOR simulates teamwork in the operating room in different real-life professional contexts. This environment was designed to be used in a learning context. We have presented a model designed to specify, record and store different kinds of objectives: “step objectives, shown to the students for them to get their bearings in the scenario, and; “failure- or “success-objectives, hidden to the students yet allowing for identifying what was missed in the scenario. Objectives are combined in a tree-like structure with a specific grammar that helps to build, out of simple contextual actions, conversations or decisions, meaningful team objectives that enable to recap their behavior and the expected outcomes. This model was used to specify educational objectives connected to the WHO surgical checklist. The behavior of students has been recorded individually and collectively during 20 training sessions and the model has successfully been proven able to reveal their successes and failures, and therefore to evaluate their teamwork efficiency in critical situations. Future work aims to design dynamic information as blood pressure that change dynamically during the surgery to build more complex scenario and its educational objectives that take in account the temporality of events.

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Students' Motivations and Motivating Students in Study Islands

Resources Needed to Tap the Full Potential of Study Islands

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Abstract. Study Islands are a setting for collaborative learning and guided self-study at a university. Success factors are identified, leading to a multi-dimensional approach: A conceptual understanding in regard to space and time, competences of the staff, and interaction between students and staff is introduced. Stake holders in the guided learning process – students, tutors, and academic staff – and their goals are identified. Developing an understanding of students' motivation to attend opens up possibilities to encourage student participation. Experiences from two study islands show that established place and time as well as face-to-face interaction between students and staff play a major role in founding a stable relationship and forming a basis for students' success.

Keywords: Study Island · Motivation · Resource Planning

1 Introduction

In our mindset, students are those who strive after knowledge, feel devoted to a subject and are eager to learn. However, especially in their freshman year some former pupils need help in becoming a student. A study island has the resources to assist students in their studies and can give additional impulses. The concept supports students in their individual study process above and beyond the lectures. In study islands, students work on their individual tasks and if necessary can get help from the staff – student tutors, scientific assistants, and professors.

In 2014, the department of Natural Sciences introduced the university's first study island: two afternoons per week, tutors and academic staff are available to help freshmen in all first year modules. Due to bilingual programs and international students, it is offered in English and German. On average, 10 to 20 students visit the study island per session, supervised by two to three members of staff. The department of Electrical

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Engineering, Mechanical Engineering and Technic Journalism (EMT) adapted the concept shortly afterwards to the needs of their students (specialization on mathematics, electrical engineering, and writing) [1]. This study island opens four times a week for four hours and is attended by freshmen and more senior students alike (15 students on average, two to three members of the staff plus some student tutors). Visitor numbers peek at the beginning of a term and shortly before the exams.

Recently, the concept was adopted by the Department of Management Sciences with long opening hours in the evening, operating almost exclusively with tutors. The "latest addition to the family" is the study island in the Department of Computer Sciences. So, now all departments offer their students a study island.

In this article, we discuss the opportunities of study islands as a form of a cooperative learning concept at university level. However, similar methods are well-established in grade school and high school (see [2–4]) and support the shift from teaching to learning [5, 6]. Here we refer to the findings from the two well-established study islands in the departments of Natural Sciences and EMT.

2 Dimensions of Study Island

Our understanding of a 'study island' is a specific learning setting of guided self-study. It[1] is characterized by three tightly interwoven dimensions and the priorities in attending vary greatly among students.

1. **Dimension of Space and Time.** Connecting a specific place and time to a specific activity is essential for settling into a work routine.
2. **Dimension of Study-Related or -Unrelated Competences.** Students, especially freshmen, may require support in developing competences e.g. in their field of study, in learning/study strategies, in communicating their questions and needs.
3. **Dimension of Face-to-Face-Interaction.** The student becomes part of a community of peers, tutors and teaching staff, profiting from their knowledge, strategies and (emotional) support [7].

It is important to note that a study island is a non-compulsory opportunity for students to engage in self-study, either alone or in small groups. Groups may emerge spontaneously or result from earlier encounters in various contexts. Students, tutors and teaching staff consider themselves stakeholders in the process of acquiring study-related competences. All parties have legitimate interest in progress being made:

- Students are primary stakeholders as their study behavior directly influences their progress in study-related tasks and ultimately their success in exams and finals.
- Secondary stakeholders are tutors and teaching staff. Their self-image is partly founded on seeing an increase in knowledge in those they work with.
- Tertiary stakeholders are the university department and the university (internal stakeholders) as well as students' families and friends (external stakeholders).

[1] The English term *study island* emphasises the spatial concept. The German term *Studierwerkstatt* is more concept-oriented.

3 Goals and Potential

The concept of the study island supports students to orient their individual study progress above and beyond the lectures towards successfully completing their studies. The main purpose is to create attractive surroundings where an independent and at the same time supervised learning process can succeed. The study island offers a place to try out study routines, to solve study tasks successfully and to create motivating learning experiences. It offers a space to achieve study success which in turn makes it easier for the student to take the next step more independently and easily. Crucial factors are on the one hand a respectful interaction and on the other hand the student's autonomous decision to apply the concept of a study island. Learning goals then do not exclusively refer to expanding the comprehension of the study contents but particularly to acquiring interdisciplinary competences such as adopting study routines, courage to recognize knowledge gaps, consciously recognizing progress and courage to share experiences.

Considering the goals from the participants' perspective (Fig. 1), differentiated viewpoints may be developed: Students focus on e.g. passing the exam, successfully preparing a lab report, solving math problems correctly or writing a grammatically and stylistically correct text. Teaching staff concentrate on imparting study routines, creating a sense of achievement and giving personal advice and learning guidance. They gain various insights into their implicit and explicit attitude to teaching, the students' perspective on everyday life. Their work in the study island is recognized by the university as part of their workload. On the other hand, student tutors experience their role as a confirmation of their own knowledge and by sharing their expertise they have the financial reward of holding a student job as well. Often, they are interested in participating in training activities for tutors and receiving a confirmation of participation and a job reference to add to their CV when applying for a job. The university eventually is initially interested in offering support in the introductory phase (first year of study) in order to enhance study success and attract students.

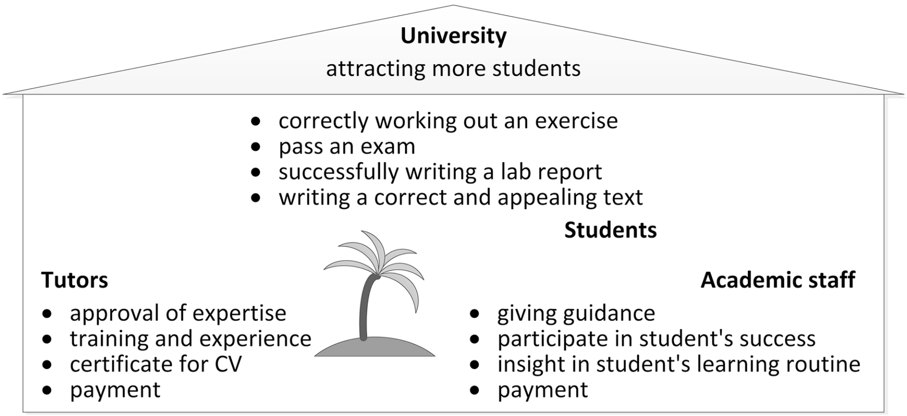

Fig. 1. Motives of stake holders in the study island

The goals can be achieved if students develop trust in the study island. This trust may evolve if students experience a respectful interaction despite possible shortcomings and realize that obstacles can be overcome step by step. These positive examples may serve later on as a template for independent work – if desired also supported by the team. The students' initiative is the crucial factor: they decide to take action, they decide to visit the study island, they decide to understand and accept the offered help as help to self-help. The following paragraph shows the possibilities of motivating students to take this step.

4 Approach

Below, we present those factors that are crucial for a successful study island and motivate students to participate:

1. **Resources of Space and Time.** To establish a study island, some resources are needed: a room and a strategically convenient time slot in the schedule. Different departments use quiet zone areas, transit zones, or designated areas in hallways. The study islands are open to students from twice per week to daily operation.
2. **Dimension of Study-Related or - Unrelated Competences.** Students are especially motivated for *Collaborative Learning* if they reasonably expect to find help and support easily, for example with isolated study tasks. Struggling to solve math problems, writing papers in a foreign language or other assignments, compiling lab reports and preparing for tests motivate a visit. Students are seeking technical, professional and stylistic support. Other members of the department may also encourage students to turn to the study island to overcome hurdles.
   Some students visit the study island regularly and stay for several hours, others drop in with a short question and leave again soon. Some use the study island to improve their performance from good to very good grades; on the other hand, many students focus on mastering the exercises, not on achieving a specific grade.
   Students feel motivated if they succeed in solving every-day study problems by enhancing *Professional Competences*. As students bring in questions from a large variety of classes, it may not always be easy for staff and tutors to provide an answer. Professional competence is required. If student and staff are not able to solve a problem, an open discussion with everyone present is initiated. In most cases approaches to a solution may be found and pursued.
   Besides professional conversations, the study island offers *Encouragement* and possibilities to talk about current events and the everyday life as a student. Students share experiences from classes and exams, discuss applications for scholarships or advise each other on special study situations. A study island may develop into an exchange platform for unofficial aspects of studying.
3. **Dimension of Face-to-Face-Interaction.** The *Trained Team* most often consists of a professor, research assistants and student tutors. It is recommended to engage in team-building measures, most importantly reaching an agreement to employ an appreciative approach and a code of conduct in the study island. The presence of a professor strengthens the reputation and standing of the study island in the

perception of students and shows personal commitment to this setting. Ready access to a professor is as important as the communication with student tutors. Their immediate study experiences make them valuable and trusted interlocutors to study island visitors. The diversity among the team members makes it also easier to carry out trouble shooting and to cover the very broad spectrum of questions and problems, deriving from all modules of the current term.

By no means should the concept of *Interaction and Communication* be mistaken for private lessons. It is all about strengthening the self-competence in problem-solving; it is not about providing the right answers. Communication is therefore inseparable from teaching and learning. This determines the style of communication [8]. Often it is a three-step process: the students phrase the problem and the staff paraphrases how they understood it, possibly more concisely and using specific terminology. Then they discuss possible problem-solving strategies. With this assistance, students are able to master their tasks and later hand them in to the tutor for revision. They receive individual feedback and may edit their paper, if necessary. In conversations between student and tutor, they not only work out answers to assignments but consider problem-solving strategies on a meta-level as well.

5 Outcomes and Lessons Learnt

The experiences speak strongly in favor of offering this concept of guided self-study. Students give positive feedback on the concept and acknowledge a major impact on their short and long term study behavior and study success. Reconsidering the expectations beforehand and the resources needed, we have gained valuable insights which can be used to further optimize the implementation of this concept [9].

1. **Dimension of Space and Time.** A crucial factor that may prove to be difficult is a strategic time-management to coordinate the students' schedules with opening hours close to compulsory lectures in order to encourage students to attend.
   Many students visit the study island according to their needs. It is therefore important to have a reliable offer at specific times in established locations. The availability of staff is to be taken into consideration. Times when the study island is in high demand are times when tutors are also under pressure, e.g. exam periods.
   Students are motivated when the staff support the study island and recognize it as a key element to develop independent study competences.
2. **Dimension of Study-Related or - Unrelated Competences.** The variety of competences all participants acquired far exceeded our expectations. The experiences may be task-related or adjusting one's point of view, concerning personal development or communication skills. It is therefore of major importance to keep the setting of a study island open-ended and to pick student tutors wisely. Attitude is just as important as grades – maybe even more so.
   Overall, in a trusting atmosphere, the topics of conversations may cover professional and didactic, informal and strategic aspects. Together with constructive feedback and motivating learning experiences, a study island becomes a motivating and encouraging place again and again.

3. **Dimension of Face-to-Face-Interaction.** Setting up a study island as a means for students to engage in direct interaction with fellow students, tutors and staff bears witness that face-to-face-interaction is considered crucial for learning and teaching. Nevertheless in retrospect, it was underestimated: in reality the concept greatly reduces the power distance between the participants.
   The style of communication is important for the students' motivation to attend. Consequently, a member of staff has several functions: On the one hand, they explain what is not yet understood by the student (push) and teach in direct contact with the student; on the other hand, they listen to the students and repeat what is already understood. They use the so-called Socratic method or maieutics to help the students to develop the answers themselves (pull). Obviously, students appreciate when a tutor or member of the staff takes a genuine interest in them.

Taking a closer look at the direct stakeholders it becomes clear that all parties may profit from a study island experience. Two exemplary case studies illustrate the multi-dimensional effects of a study island:

Case Study from the EMT Study Island
Student Ava visited most study island sessions. Her motivation was high as she had failed a specific math class once already. She claimed to know how to 'calculate' but to have trouble to 'think'. Ava became more and more confident in recognizing underlying patterns, structuring math word problems, choosing an adequate way of working through the problem and avoiding careless mistakes.

After the exam, the professor informed the team that the 'non-thinking' and hectic student had spontaneously recognized in the exam that an equation could be greatly reduced in complexity and found the solution easily. Agreeing that the student's solution was correct and more elegant than her sample solution, the professor gladly granted the full mark for this problem.

In the study island, Ava had learnt to 'think', i.e. to look closely at a problem, comparing it to known exercises and to take her time. In this example, we observe Ava's progress in her attitude to studying, setting goals and her self-esteem. 'I can't do it' changes to 'Let's do it!'. She is a primary stakeholder for her own progress and admits this to herself, bearing the consequence of being held responsible for her doings.

Case Study from the Study Island Natural Sciences
Student tutor Raymond was very successful in his own study course. While teaching in the study island, he got positive feedback. These experiences strengthened him in his belief of his abilities. Motivated, he decided for an application on a scholarship, encouraged for the following demanding interviews. He was successful and got two renowned offers. Today, he is enrolled in a highly prestigious master study course. Raymond told us that the experiences in the study island were really useful for him. Teaching experiences supported him in his own learning processes and gave him the necessary self-confidence.

It becomes also obvious that the department and its staff are involved in the progress. It is appreciated that colleagues worked with their student. The study island does not only support the students, often it is productive for student tutors, too.

Generally speaking, student tutors are well-aware of their personal benefits: although they appreciate the monetary compensation, they enjoy teaching other students, as well as a redefined relationship to the academic staff and the opportunity to follow up lessons from earlier terms (revision).

6 Summary

In this section, we try to give – prioritized according to their perceived relevance – some recommendations for successfully implementing a study island.

1. **Face-to-Face Interaction and common goals.** First of all, the study island is face-to-face. We welcome each student entering the study island individually. We also ask what they intend to do on that particular day. Virtually all students and tutors in the study island agree that this classic setting is the best way to study and that regular contact provides a basis for acceptance and confidence in each other. Students know that they are supervised in a positive atmosphere due to respect and confidence in the study island. This encourages hard work and it is always motivating for students if their newly acquired competences are noticed. Finally, the study island is centered on learning and is less distracting than one's home.
   Online elements may complement the study island. We plan to provide short videos on frequently asked questions, e.g. inequations. This aims to shift time from teaching to assisting the learner in the learning process and to foster self-learning competence.
   All players in the study island – students, tutors and academic staff – work successfully together if they have a sense of having common goals. This is backed by an atmosphere of trust, respect, and self-esteem.
   Individually, students want to be successful, i.e. they want to pass their exams or get full marks for a lab report. Tutors want to gain experience, a certificate of their activity for their CVs, and earn some money. They profit as they refresh their technical knowledge while explaining matters as well as acquiring teaching skills. For academic staff it is attractive to participate in (some) students' success, to gain

insight into students' lives. Working in the study island should be a recognized part of their teaching load as the department is also interested in student success rate in order to attract students.

Tutors are important for the atmosphere in the study island as they have a mediatory role. On the one side, they are students themselves and have 'street credibility'. They can talk peer to peer to learners. Other students trust the tutors due to common experiences. On the other side, tutors are trained and part of the teaching side.

2. **Competences.** All staff in the study island must value the students and their goals. Tutors should be trained appropriately. All should be open-minded and have broad technical and methodical competences. The study island should be known all over the place and be esteemed by colleagues (and students). Then these will 'send' students with concrete tasks to the study island, for example to improve a lab report. Learning in the study island should provide students with both a challenge and a sense of achievement. The 'teachers' in the study island are in charge to guide students to help themselves and to make them recognize that they did so. A repeated sense of achievement is the best motivation for mastering one's study. Therefore, the academic staff needs listening skills. They must be available to give guidance and need to give the students space to learn and solve problems themselves.
3. **Resources of Space and Time.** As the study island is a face-to-face setting, it depends on having a room. Therefore, we meet at one and the same location at regular times. Reliability and commitment are trained by this regular setting. This is particularly important for students who are not yet used to studying independently. Student's timetable should include free time for visiting the study island which should be placed directly before or after mandatory courses. This helps to keep the threshold low. Additionally, there should be a common understanding in the department, that it is appropriate to invest time, competence, and teaching load in supporting the study island. Students appreciate that academic staff is present.

We thank our colleagues for taking an interest in the study islands and integrating them in the concepts of the departments. Special thanks go to our respective team members Roberta Hodel a.k.a. the math expert and Antje Thielen.

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Using the System Usability Scale in a Classification Learning Environment

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Abstract. The System Usability Scale (SUS) has become an industry standard where survey participants are asked to rate ten predefined questions on the scale range of strongly agree to strongly disagree. CIRCLE (Classification, Identification, Retrieval-based Collaborative Learning Environment) is software which lets students learn and gain real time knowledge about classifying objects like plants and animals or rocks and minerals. This paper compares the results obtained by SUS surveys done on CIRCLE in its early and later versions.

Keywords: User-centered design · Usability · Classification learning · Gamification

1 Introduction

The usability of educational media, or any software system, is of paramount importance to its success. The Information Superhighway is littered with the rusting hulks of software systems that were hard to understand and use. The system usability scale (SUS; Brooke 1996) was developed as a simple, ten-item Likert scale for the subjective assessment of usability.

The System Usability Scale was used to determine the usability of the Classification, Identification, Retrieval-based Collaborative Learning Environment (CIRCLE). CIRCLE is an improvement over standard Identification and classification games which abound on the Internet and in mobile app stores (App Shopper 2013; AmericanTorque.com 2013; Crimson Trails 2013; Kids Know It Network 2013; Kinder Web Games 2013). Rather than socially-mediated, actively constructing knowledge, as in Vygotsky's social constructivism (Vygotsky 1978), these identification games provide a method for retrieval learning. This theory suggests that the act of retrieving knowledge in multiple different ways results in better learning outcomes (Karpicke 2012).

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2 Background

2.1 The System Usability Scale (SUS)

In an SUS survey, participants are asked to rate ten predefined questions on a five point scaled range from strongly agree to strongly disagree. Each response is scored with a value from 5 (strongly agree) to 1 (strongly disagree). Such surveys have been used to determine the usability of a wide range of computer applications (Bangor et al. 2008) and provides an excellent test of CIRCLE's usability. SUS ratings and associated comments solicited in a separate survey informed changes made to improve CIRCLE.

2.2 SUS Scoring

The SUS score is calculated by performing the following steps: (1) For odd numbered SUS questions (see Table 1), subtract one from the user response (2) For even nu-mbered SUS questions subtract the user response from 5 (3) This scales all values from 0 to 4 (with 4 being the most positive response) (4) Add up the converted responses for each user and multiply that total by 2.5. This converts the range of possible values from 0 to 100 from 0 to 40. (Sauro 2011)

Table 1. The ten questions used in the CIRCLE's version of the system usability scale (SUS) survey.

1. I think that I would like to use CIRCLE frequently
2. I found CIRCLE unnecessarily complex
3. I thought CIRCLE was easy to use
4. I think that I would need the support of a technical person to be able to use CIRCLE
5. I found the various functions in CIRCLE were well integrated
6. I thought there was too much inconsistency in CIRCLE
7. I would imagine that most people would learn to use CIRCLE very quickly
8. I found CIRCLE very cumbersome to use
9. I felt very confident using CIRCLE
10. I needed to learn a lot of things before I could get going with CIRCLE

2.3 CIRCLE (Classification, Identification, and Retrieval-Based Collaborative Learning Environment)

The CIRCLE system was developed to help students learn how to classify and identify real world objects. Students work collaboratively to (1) gather specimens, (2) identify important observations and experiments about those specimens, (3) classify the specimens with respect to the results of these experiments, (4) provide a name or other identification for the specimens, and (5) play games dynamically generated based on the information gathered by the users (Borchert et al. 2015).

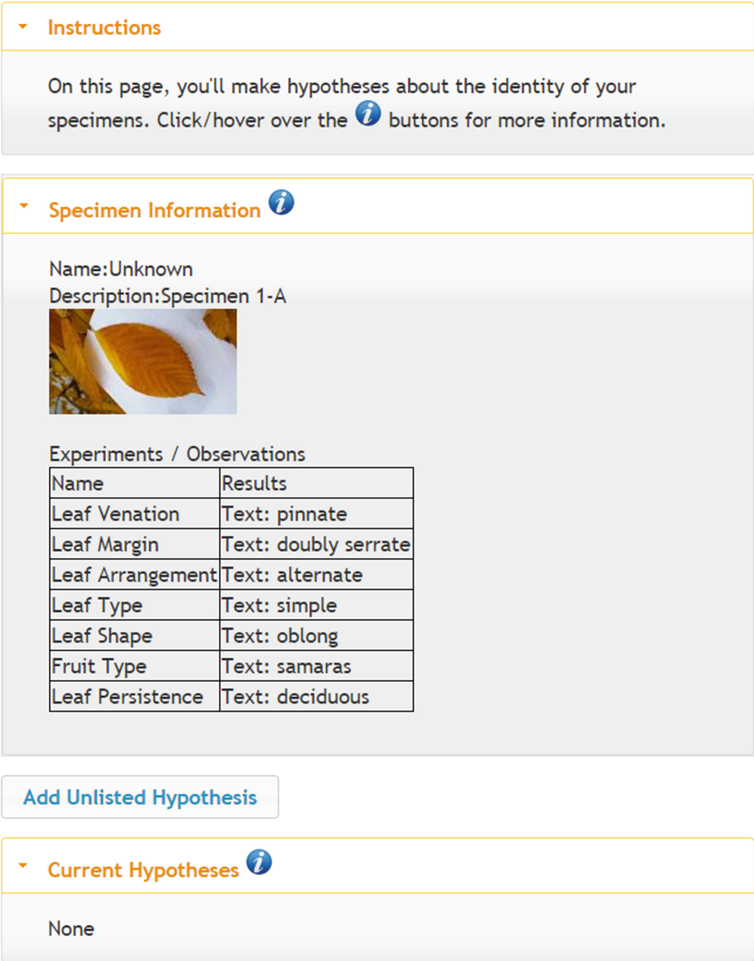

Fig. 1. The interface for identifying a specimen with all of the multimedia and experimental results for an individual specimen.

CIRCLE players begin by finding interesting objects in their environment (Fig. 1), providing intrinsic motivation to the task (Deci and Ryan 2000). Players take pictures of these objects, referred to as specimens, using their mobile devices. Some example objects include trees, birds, rocks, weeds, or any other classifiable object.

After gathering specimens, group members suggest experiments and observations to perform on the specimen. Possible experiments for leaves might include leaf shape, leaf arrangement, or bark color. These suggestions are then performed by the gatherer, with the results being stored in the game for use in future tasks (Fig. 2).

After a number of experiments have been performed, players are able to create classification structures based on this data (See Fig. 3). Students use a click and drag interface to create a classification tree. Branches of the tree refer to individual

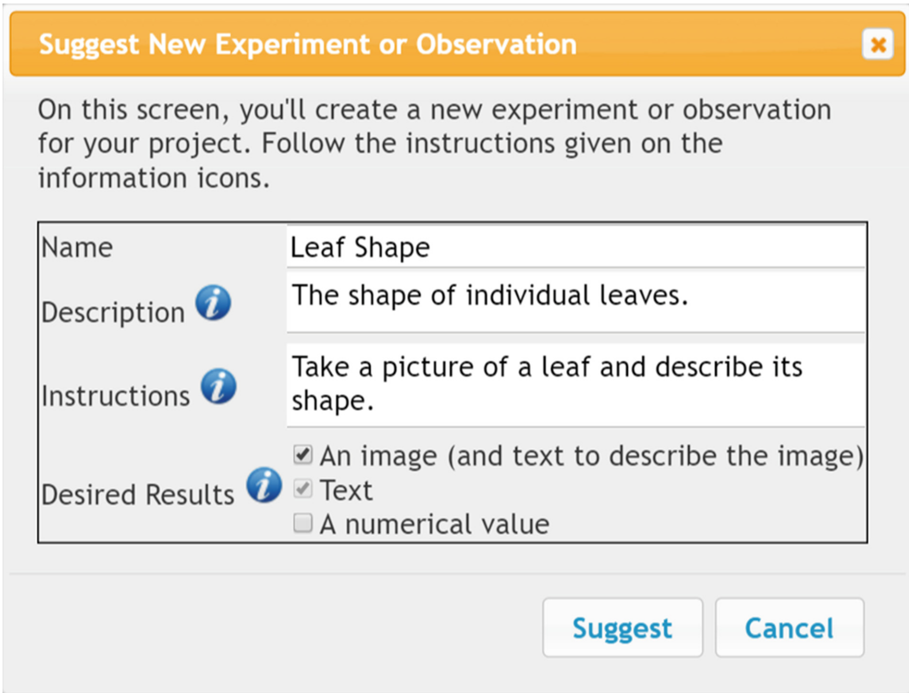

Fig. 2. The interface for suggesting new experiments. After an experiment has been suggested, the gatherer needs to complete the instructions using an image, text or numerical result. The user is suggesting a leaf shape experiment which includes taking a picture of an individual leaf.

experiments, while leaves in the tree correspond to specimens. The classification is deemed correct when all gathered specimens can be classified by the structure.

After classification, players identify the individual specimens. Students create a hypothesis to name each specimen group from the classification structure (see Fig. 4). All players in the group then vote on which hypothesis they surmise accurately identifies the specimen. Whenever a majority has voted for a specimen name, it is given that name in the interface.

After all of these tasks are completed, players unlock a game interface, where they can play games based on the data they collected: the specimens, experiments/observations and results of those experiments/observations, classification structures, identities, and any gathered multimedia. This data is used to create a game that helps solidify student knowledge through retrieval learning (Karpicke 2012). Rather than simply attempting to memorize their specimens, they need to actively retrieve their knowledge from memory (Fig. 5).

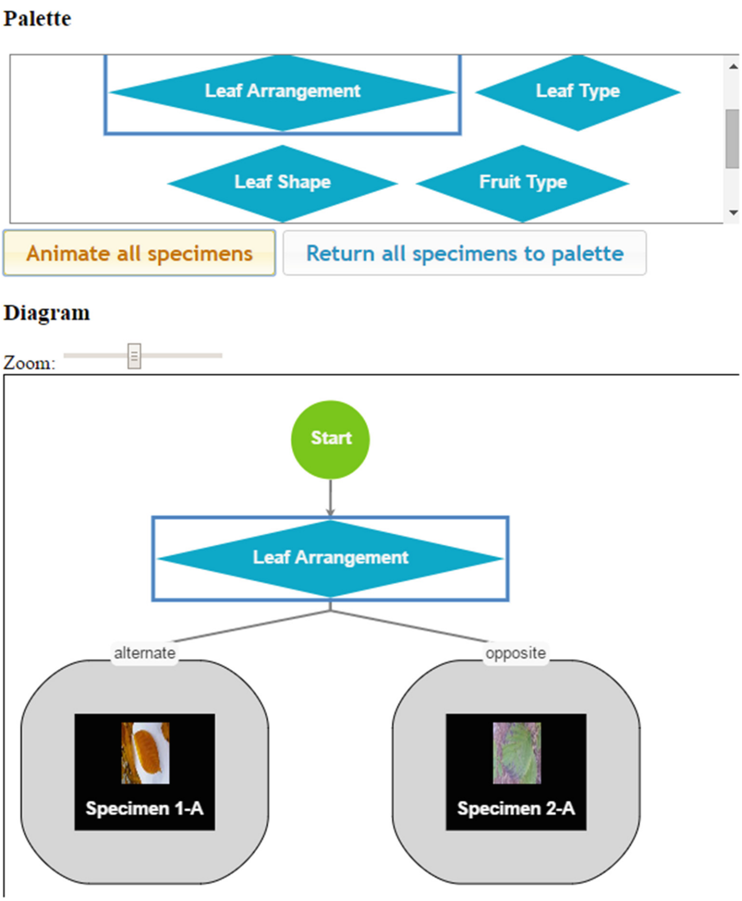

Fig. 3. A screenshot of the classification interface. Students are able to drag experiments from the palette at the top into the diagram area at the bottom. These actions are displayed to all players in real time. Specimen 1-A and B are in different specimen groups and will be assigned different names.

3 Methods: The First Survey

Undergraduate biology students played the first version of CIRCLE as part of a larger class exercise on tree phenology. Groups of two to four students were asked to visit a series of trees and use CIRCLE to identify and classify the trees. These participants were also asked to fill out the 10-item System Usability Scale survey (Table 1) and a 4-item open ended questionnaire administered as a means of gathering information about the ease of use of CIRCLE.

The open ended questions included “What things were good about CIRCLE? Why?”, “What was bad about CIRCLE? Why?”, “What should be changed about

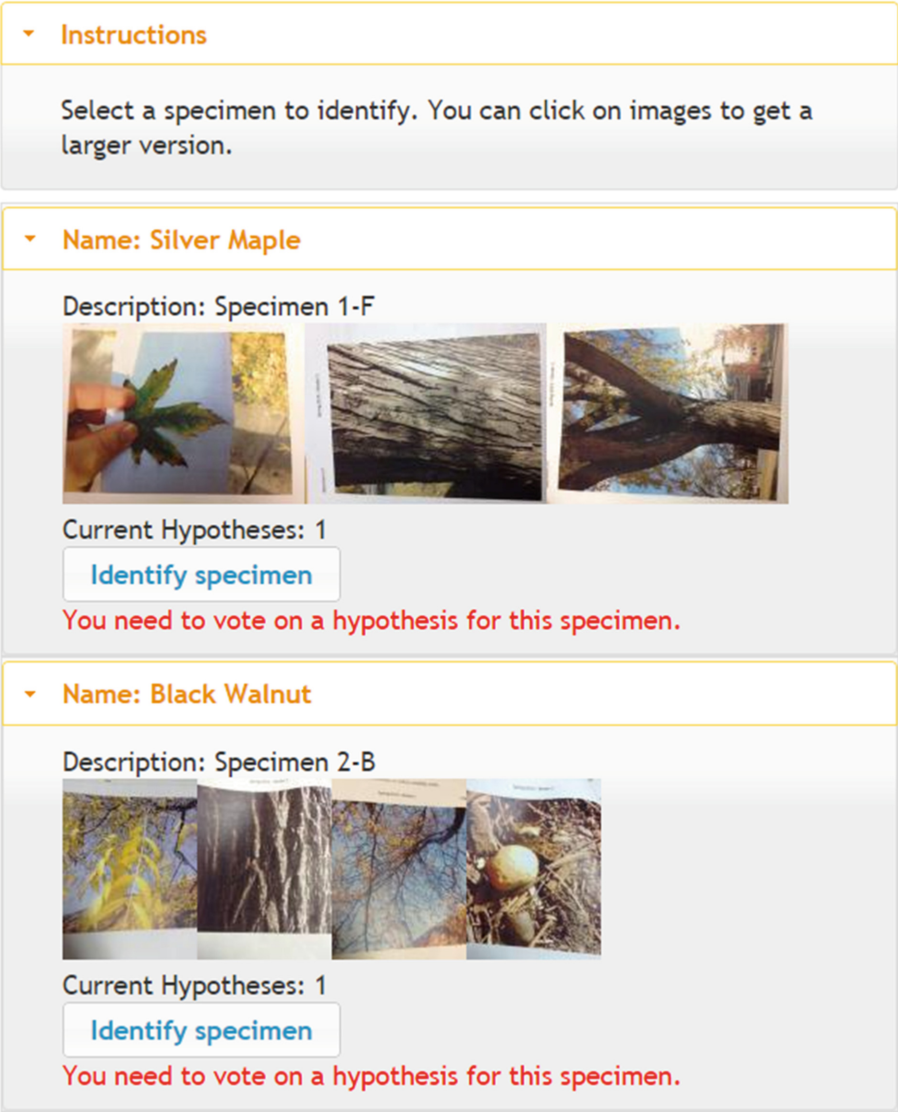

Fig. 4. Two separate specimen groups that have been positively identified.

CIRCLE?", and included an area to add additional comments. In the SUS instrument, users expressed an opinion on a five point Likert scale from Strongly Agree to Strongly Disagree.

The responses to the open ended questions were then correlated with individual SUS questions. For example, SUS question #5 is "I found the various functions in CIRCLE were well integrated" and user comments included (referring to using the color red as a visual cue in CIRCLE) "Red prompts for what to do next".

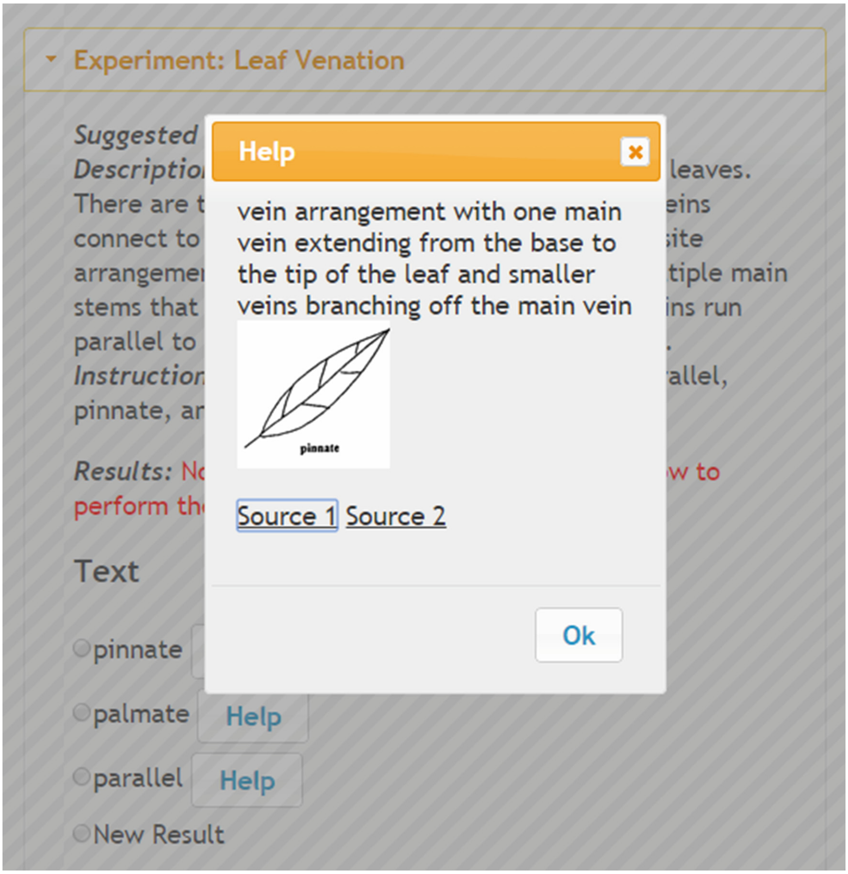

Fig. 5. Improvements to CIRCLE included more help information. This help entry gives more information about a pinnate leaf arrangement.

By contrast, SUS question #6 is "I thought there was too much inconsistency in CIRCLE" which prompted one user to add "Unable to go back and change things", and another to suggest "add home button". A total of about 20 concrete and implementable suggestions were provided.

The next version of CIRCLE addressed many of the suggestions offered by the pilot study group, and the next experiment administered another SUS questionnaire, with the responses tracked by SUS question number. In this way, we methodically tracked and measured the improvements in the second release version using changes in SUS scores.

4 Results: The Revisions

The mean SUS score for the first experiment was 41.1, well below average for an application like CIRCLE (Bangor et al. 2008). Student answers to the open ended questions provide insights into the low SUS score. Answers were categorized to identify the most important issues to address. The top five answers to "What was bad about CIRCLE?" were related to tree construction, not liking working in groups, being unsure what to do next, difficulty in navigating, and bugs in the software. The top five answers to "What should be changed about CIRCLE?" were: improve directions, improve tree construction, make the interface more user friendly, and remove group work. Despite student objections, group work was not removed. This is a hallmark of the CIRCLE experience and is grounded in educational theory. The other issues were matched with specific developer tasks in an effort to improve system usability.

Tree construction improvements included (1) a complete rewrite of the classification tree interface as described shown in Fig. 3; (2) the creation of a tutor dialog box that appears when students unlocked a component of their classification tree: specimens, experiments, and results; (3) creation of a tutorial video for developing a classification tree; (4) inclusion of embedded node data, allowing users to see the information related to a particular node in the tree. For example, clicking on a specimen would show its multimedia, name, and experiments in the information panel.

Directions were improved by implementing a series of tutor messages for each stage of the CIRCLE process, with special emphasis on interface elements. This is related to the issue of being unsure what to do next. In addition to the tutor messages, context-sensitive red text was used to indicate what the user needed to do next. For example, when students are required to vote for a particular specimen, red text is shown next to those specimens in the list.

Difficulty in navigation was improved by creating a cookie crumb navigation bar (Levene 2010), where players can visit any page in the hierarchy that is immediately above the current page. Prior to this, the navigation buttons were always on the bottom, and it was not always clear to students how to navigate the interface. A graphical site map (Peruri 2016) was also developed.

User friendliness was increased by adopting the JQueryUI framework. This allowed the developers to quickly create more graphically pleasing and consistent interfaces without the assistance of a trained artist.

In addition to these written comments, it was noted by the instructor that students were not sure why they were performing the tree classification task. This was primarily because students were performing identifications using Internet-supplied dichotomous keys. This issue was alleviated by swapping the identification and classification tasks, so that classification came first. This also allowed for the ability of the classification tree to handle two specimens with the same experimental results, giving them both the same identification through the use of specimen groups as described in the implementation.

5 Methods: The Second Survey

The next release of CIRCLE was deployed in a setting analogous to the first release. Data gathered during the first experiment was used to create binders of specimens with identities removed. Participants of the second survey used the binders in concert with a list of possible identities for the specimens to identify and classify the set of trees again.

Groups of two spent approximately four hours identifying and classifying 11 different kinds of trees and playing retrieval-based games produced by CIRCLE.

6 Results: Measurable Improvement

The SUS data was analyzed. The mean SUS score for this study was 68.0, with a standard deviation of 15.3, this is significantly better than the score in first experiment ($p < .001$ on a two tailed between subjects t-test). Comments were generally favorable.

Even though many issues have been solved after the first survey, a few issues were repeated and some issues in classification structure and tree animation have increased. Some new problems were faced with the pop up notifications and long tutorials. The number of users complaining about these issues was comparatively more in the second survey as compared with the first. This affected the overall SUS mean score as these comments were not expected. This is the main reason for not getting a very good score in second survey. These issues are to be solved in future work.

7 Discussion and Future Work

This project has helped in understanding the users' point of view using the System Usability Scale questionnaire to gauge their comfort and understanding level while using CIRCLE. The comments obtained helped improve the user interface and its usability. The idea of developing a sitemap was very effective as it helped the users to navigate around CIRCLE. These results were amplified when the second review was conducted, as the number of comments was reduced and the positive aspects of CIRCLE increased. Users experienced better performance than before.

Future work will involve improving the efficiency of CIRCLE by rectifying the drawbacks which showed up in second survey. For example, providing an instructions page which will help the users know what to do next, tree animation and uploading images should be made more user-friendly. The performance of the system can be improved as the system freezes sometimes resulting to loss of unsaved user data. A few buttons can be added, like the "save" button for "Elaborate specimens" rather than saving each procedure, and a "back" button will be more helpful to modify or make changes as necessary.

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Student's Behavior in Virtual Environment

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Abstract. The analysis of students behaviour in web learning environment within distance learning is one of the most significant areas for learning optimization. The aim of this article is to analyse student's behaviour and the use of e-learning course in subject Discrete Mathematics. Data and results of this analysis are important for further adjustment and improvement of the e-course. Results of the course traffic analysis were estimated using association rules Discrete mathematics is compulsory for both bachelor and master study program Applied Informatics in full-time and distance form of study as well as bachelor and master study program Teaching of academic subjects in full-time and distance form of study. This electronic course is designed to use linear and branched teaching programs. In compiling the course we tried to take into consideration target audience - students of Computer Science. The course is designed to not require any special knowledge in IT field. Discrete Mathematics Course 1 consists of 10 thematic units (areas) replicating the length of the semester in weeks. Authors describe detail analysis of student's behaviour which is made of data taken from LMS MOODLE database. We used specific types of data, which are indicating user traffic on every single page of the course. We used a log file that contains records of e-learning course with 107 students. To identify sessions, we used the STT (Session Timeout Threshold). Purpose of session identification is to divide access of all users into separate sessions (relations). Session side-effect may exclude users who are behind a NAT or proxy device. So we can identify users who are sharing a single computer, for example in a library. Students who used the e-course of Discrete Mathematics 1 were more successful in the final examination. The fact that the course is effective does not mean that all activities have been fully utilized. Based on the results of our analysis, we can optimize and improve the e-course and bring it closer to the student's needs. After implementation of necessary changes we can evaluate impact of these changes in the efficacy of the course.

Keywords: Discrete mathematics · Data mining

1 Introduction

In recent years, university education has undergone major changes not only in content but also methodological aspects supported by information and communication technologies (ICT). The use of ICT does not only offer the tools used in primary form of study either full-time study, but also new forms of learning. At universities, in addition to full-time study increasingly gets to the forefront distance learning. This attitude may

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result not only from the actual lifestyle changes, improving the knowledge and ICT skills, but also from the large number of people who desire for university education.

Nowadays, the distance study is considered as the most effective form of study. The principle is to use an amount of IT options and the teaching of IT devices within the teaching process, as much as possible. This allows students to study independently at their own place, anywhere and anytime. That is why it is very important and necessary to put special emphasis on creating teaching aids, such as electronic learning materials and e-learning courses. To achieve the highest learning skills it is necessary the optimization of electronic courses.

The aim of our work is to analyze the use of the Discrete Mathematics course, which is one of the compulsory subjects taught at the Department of Informatics. Data and analysis results are important for further adjustment and improvement of the e-course. The results of the analysis of traffic on the course were estimated by using association rules. Learning environments that we used in teaching and, consequently, in research, is the Content Management System (CMS). In the research we used mainly educational data mining methods by which we obtained association rules that we have analyzed.

2 Related Work

CMS provides many features that can enhance learning, especially the area of distance learning. Examples of commercial CMS systems are Blackboard [1] or TopClass [2]. Examples of free available systems are Moodle [3], Ilias [4] and Claroline [5]. Nowadays, one of the most commonly used is Moodle (modular object oriented developmental learning environment), a free Learning Management System (LMS) enabling the creation of powerful, flexible and engaging online courses and experiences [6]. The spread of online technologies as Moodle has been widely analyzed at faculty level, as for example in San Francisco State University (SFSU), where the 70% of all courses use online technologies [7, 8]. Moodle normally use a relational database to store the large data log of the students activities and usage information. And although some platforms offer reporting tools, if there are a great number of students and a great amount of information, it becomes difficult for a tutor to extract useful information. Recently, some researchers propose using data mining techniques in order to help the tutor in this task [9].

Data Mining (DM) is a computer-based information system (CBIS) [10] devoted to scan huge data repositories, generate information, and discover knowledge [11]. The use of DM in the education arena is incipient and gives birth to the educational data mining (EDM) research field [12]. EDM pursued to find out patterns and make predictions that characterize leaners behaviors and achievements, domain knowledge content, assessments, educational functionalities, and applications [13]. EDM is a relatively new area of scientific research, which arose as a natural consequence of the Internet penetration, modern statistical methods and e-learning itself [14]. Since different VLEs gather an amount of data about their users, their work and practices, it seems to be a good idea to use advanced statistical methods for data analysis.

EDM can be characterized as a research area that deals with the development of new techniques and methods, testing new theories of teaching, finding patterns of different types of user behaviour in structured and non-structured data [14]. These date are generated by VLE, educational software, intelligent and adaptive education system or by a specialised software for testing. We can find models that allow the adaptation of learning paths according to the student's "on-site" progress [15]. Most attention in the professional community focused on areas such as "big data", business inteligence, footprint, adaptivity or data mining. The EDM arose as the consequence of using those concept in education. The main objective of EDM is to analyse data from VLEs, which collect an enormous amount of data, and find answers to difficult questions about the learning process as well as the entire e-learning. EDM aims to develop methods for better understanding of students' behaviour and the learning process itself, using VLE or any educational software respectively [14]. VLEs became more and more complicated, sophisticated and complex at present. Therefore, the amount of data produced by these systems has increased rapidly. It is important to mention several important and unique features of these data [14]:

- Hierarchical structure (student's activity level, user's session level, level of students' class, course level).
- Temporal character, which allows measuring the duration of a particular activity or session.
- Sequences, which can be used as course building blocks and ordered in the best suitable manner.
- Context, which is very important for the explanation of results obtained.

The EDM focuses on solving problems, which arrive in different phases of learning process. These problems relate with primary application domains of the EDM [14]:

Data analysis and visualization, Decision support of teachers, course developers and managers based on the feedback, Recommendation to students, Student performance forecast, Student modelling, Detection of student's undesirable behavior, Study groups and teams creation, Student social network analysis, Conceptual maps development, Course content and structure design, Time table planning.

Nowadays a lot of attention is focused on Web log mining. Examination of log files or user behavior on the website, has a several approaches. An overview of these approaches is described in the publications of Koutri et al. [16] and Kostala and Brlockeel [17].

3 Data Source and Pre-processing

We obtained Data Source from the database. For this reason, this area is also often known as web log mining. In this data we follow the sequences in visiting each course page of user. Each row presents notice about user ID, IP address, the time and the date of the visit, the approaching object etc. We used log file that contains the entities from the e-learning course with 107 students.

With analysis of the user log-on data we can better understand the behaviour of the student in an electronic learning environment. For this purpose the following adjustments (corrections) are made [18]:

- Data cleaning, data transformation, data integration.
- Identification of sessions, where the session may be defined as a sequence of the steps, that lead to completing the concrete task [19] or as a sequence of the steps, that lead to meeting the concrete target [20]. The simplest method is if we consider the series of clicks in a defined period of time [21].
- The reconstruction of activities of a web visitor. Taucher and Greenberg [22] proved that more than 50% of accesses to web are via backward path. Here comes the problem with the cache of the browser. By the backward path, a query for web server is not running, thus there does not exist a record in the log file. The solution to this problem is path filling. With path filling we add these missing rows into the log file [23].

By the data preparation we took into account recommendations resulting from series of experiments examining the impact of individual steps of data preprocessing on quantity and quality of extracted rules [24–26]. Researched nominal variables are variables “sites of course” and “activity in the course” with the categories: Book (book), Page (page), Course (course), Forum (Forum), Quiz (quiz) and Source (resource). Sequence/ID variable step is such a program which identifies the approaches according to the user ID, IP addresses and time (131 s duration time window). The investigated multiple response variables are a variable Course page and a variable Course Activity with categories: assignment, book, course, feedback, forum, glossary, quiz and resource. The sequence/transaction ID variable is a variable Session which identifies sessions based on user ID, IP address and time (131-second-long time window) [27].

A. Session Identification

Session refers to a series links made by one web-user to get information on a certain topic. At present, there is some arithmetic approach for session identification - Hvist, where user’s access time to the whole website will be given an upper limit, usually 30 min, Hpage where users’s access time on one page will be given an upper limit, usually 10 min, and Href which is classified according to user’s access history and reference pages [28]. For session identification, we use a Session Timeout Threshold (STT). Other common methods are identification based upon Access Time Threshold and session reconstruction. The aim of session identification is to divide accesses of every user into separate sets. Session can eliminate the side effect (anonymity) of users behind NAT router or proxy server so we can identify users which share one computer, e.g. in the library. The STT method divides the session into smaller ones when it finds accesses to the web page from the same source with a higher interleave than the set time period - time window. The appropriate size of the time window evolves the quality and quantity of behaviour patterns found. We estimate the value of time windows based upon the duration of the visit - Length variable. We calculate the Median, quartile range and non-outlier range of the Length variable. The non-outlier range is created between the last value of QIII + 1,5Q and the last value of Length above QI − 1,5Q. Values outside this interval are considered as outliers (Table 1).

Table 1. Descriptive characteristics of variable length

	Length
Valid N	10130
Median	16
Minimum	0
Maximum	3586
LowerQ	6
UpperQ	56
Range	3586
QRange	50
=UpperQ + 1;5 *QRange	131

Our focus is on the upper limit of the non-outlier range. Values that are higher than 131 are considered outliers. The number 131 is the size of the time window. When the time between accesses to website from the same source is longer, a new session begins [29].

4 Usage Analysis of Course Activities

Graph (Fig. 1) visualizes found association rules. The size of each node in the activities supports the activity. The thickness of the line between the activities visualizes the level of support of the rule, resp. the combination of the two activities. The brightness of the line shows and the lift of the rule determine what lift as the pair of the activities occurring in one sitting together against their occurrence separately. If the value of the lift is greater than 1, the pair often appears together during one session in the set of visited pages. In the graph (Fig. 1) according the size of the node, we can see that the most visited page is the page Course, which has 65.3% support (support). Other

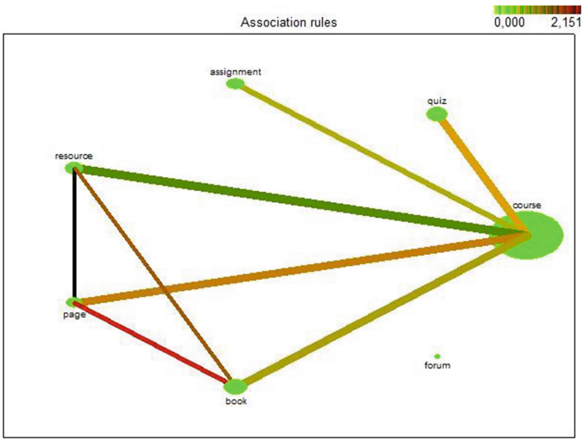

Fig. 1. Visualization of the found rules: Web graph

activities that were more than 10% supported are: Book, Quiz, Source and Page. Below the 10% remained the activity Forum. The most visited pairs (Fig. 1) Course-Book, Course-Source, Course-Page and Course-Quiz (support > 10%), which means that in more than 10% of the sessions was at least one of these pairs. The support of other combinations was less than 10%. The value of lift was higher than 1 in pairs Page-Source, Book-Page, Book-Source and Page-Course. This means that the activities Page (solved or unsolved problems), Source and Book were more frequently appeared in sessions in pairs than alone.

The following graph (Fig. 2) visualizes the reliability of association rules. The size of the node shows the support of the rules and brightness of node, reliability of the rules. Reliability is dependent on the orientation of the rules, because it is the conditional probability of finding the occurrence of the conditions provided for in the set of visited pages.

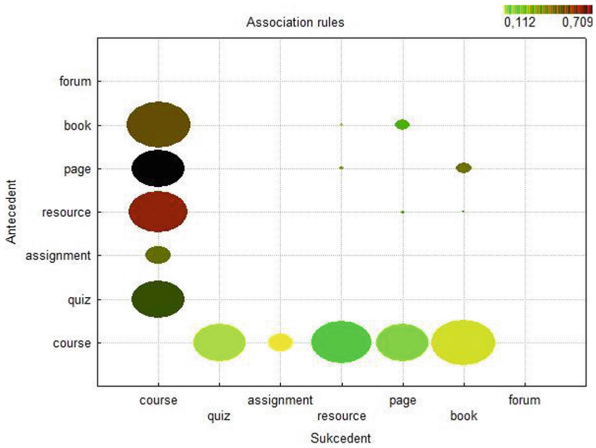

Fig. 2. Visualization of the found rules: Rule graph

In the graph (Fig. 2) we can see that the rule Page => The course has 71% of reliability and it is the highest reliability, but this rule in the opposite orientation, thus Course => Page is only 16%. A similar percentage difference is in the several pairs in combination with the activity Course. This difference sounds logical, since it is highly likely that the student returns of any activities to the main course page. But not at each visit, at which very likely will visit activity of the course appears every other user activity. These differences are in the graph (Fig. 2) visible based on the brightness knots.

5 Conclusion

The fact that the course was effective, does not mean that all activities have been fully utilized. As was shown in our research, the students mainly use the module Book. Book consists of theoretical training materials, which are supplemented by interactive multimedia elements. Another frequently used part of the funds were Resources. Resources include links to further study of the topic as well as interactive, multimedia applications. The third most frequently used activity was Quiz with an immediate feedback. Least used activity was Forum, which indicates a greater support to motivate students to discuss with the teacher and with each other about the handouts. The pairs of activities Page, Source and Book were appearing more often than separately, which means that during the study the students tried to draw at each session from multiple sources in the course, not just one. Based on the results of our analysis, we can optimize the e-course and thus we can streamline and bring it to the needs of students. After making the necessary changes, we can assess the impact of changes on the efficacy of the course.

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Learning Groups for MOOCs Lessons for Online Learning in Higher Education

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Abstract. When there is interaction within online learning groups, meaningful learning is achieved. Motivating and sustaining effective student interactions requires planning, coordination and implementation of curriculum, pedagogy and technology. For our aim to understand online learning group processes in order to identify effective online learning group mechanisms, comparative analysis was used on a massive open online course (MOOC) run in 2015 and 2016. Qualitative (interaction on the platform) and quantitative (survey) methods were used. The analysis revealed several possible ways to improve group processes. In particular, this paper concludes that course organization helped in increasing individual participation in the groups. Motivation by peers helped to increase sustainability of interaction in the learning groups. Applying these mechanisms in higher education can make online learning groups more effective.

Keywords: Online learning groups · MOOC · Higher education · Online learning

1 Introduction

The proliferation of ICT in teaching and learning has created new possibilities for supporting collaborative and cooperative learning in distance learning (Muyinda et al. 2015). Collaborative learning hinges on the belief that knowledge is socially constructed although each learner has control over his/her own learning. Vygotsky argues that a person's learning may be enhanced through engagement with others. Learning groups have been preferred for propelling interaction and learning. However, motivating and sustaining effective student interactions are not easy to achieve. That requires planning, coordination and implementation of curriculum, pedagogy and technology (Stahl et al. 2006).

Learning groups have been widely used to enhance learning in higher education and more specifically in distance learning. This is done by giving group assignments to help in the initiation of learning groups. However, challenges of co-locating students and participation of each group member lead to some students not participating on the group assignment. Often, their names are still attached to the work. This causes high failure rates at the end during summative assessment (Aguti et al. 2009), since the

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students that do not participate, fail to harness the benefits of the rich learning experiences from group members. Therefore, effective ways of engaging learners online can offer possibilities of enhanced interactions among students in learning groups.

This study was carried out on a MOOC titled “Success - Unleash Yourself” run by the University of Agder using the NovoEd platform[1]. The course has been run twice in 2015 and 2016 each from January to March. Our study is aimed at understanding online learning group processes in order to identify effective online learning group mechanisms. Online Learning groups can help to bring distributed students together to work. The goal was to establish processes of effective online learning groups in the MOOC. The research questions to be answered are how to form effective learning groups and how to sustain effective online learning group’s processes. Further on, we answered the question of how to increase interaction of students during online learning group process. Interaction is usually encouraged so as to increase learners’ engagement when completing group assignments.

Collaborative learning refers to instructional methods that encourage students to work together to find a common solution for a given task (Ayala and Castillo 2008). Collaborative learning involves effort by groups of students who are mutually searching for meanings, understanding or solutions through negotiation (Ashley 2009; Stahl et al. 2006). Collaborative learning occurs where there are interactions. Anderson in his online learning framework argues that for meaningful learning to happen, there must be high interaction in any one of the student-teacher; student-student and student-content interactions (Anderson 2003). Mayende et al. (2014) and Stahl et al. (2006) also asserts that learning takes place through student-student interactions. Ludvigsen and Mørch (2010), found out that students effectively develop deep learning when supported by computer supported collaborative learning. Therefore, a well-structured course to enhance group work can enable student-student interactions in computer supported distance learning (Mayende et al. 2015). Collaborative learning is based on consensus building through interaction by group members, in contrast to competition. Collaborative activities are essential to encourage information sharing, knowledge acquisition, and skill development (Collison et al. 2000).

The rest of this paper is organized in four sections. Section 2 presents the approaches and our research methods. In Sect. 3, presents the findings of our work and discussions. Finally, the paper is concluded in Sect. 4.

2 Approaches and Methods

This section describes the course design for learning groups and the research methods used. This is described in the following subsections: modules, learning groups, student support and methods.

[1] https://novoed.com/success-agder-2016

2.1 Modules

The course was composed of four modules with specified tasks and activities, paced according to a course calendar. Students were expected to complete all modules. The first module takes two weeks to establish the background and to connect the students. This helps in establishing social connection among students so that forming learning groups becomes easy. After that there are three modules that last for two weeks each and all of them follow the same basic structure (see Table 1 below). The last week is used to wrap up the course and to sketch the way ahead.

Table 1. Basic timeline for a module

Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu
0		1			2	3	4		5	6			7		8		9

Table 1 shows the timelines for a module with the following activities.

- At point "0" the module content and the tasks for the first week are announced.
- At point "1" the first task is reading of the theory presented. This helped the learners to underpin their discussions in the open forums on the module theories.
- At point "2" individual students answer to the group activity as a starting point. This helped in building initiation into the group activity. Each learner comes into the group with their opinion about the group activity. This helps to increase participation in the learning group.
- At point "3" the reading is concluded with a quiz. This helped to assess the learners on the theories of the module. The quiz is developed in such a way that the learner can attempt the quiz three times. In each attempt the learner is given detailed feedback which enhances more learning about the theories.
- At point "4" tasks for the second week are announced.
- At point "5" the deadline for group hand-in is reached. This hand-in is based on the group's discussion and individual student answer to group task. It is during the group deliberations that the groups agree on final submission and the member who submits.
- At point "6" learners start working on individual hand-in with emphasis on group support. The team members are encouraged to consult their teams when working on the individual activity which is connected to the group activity but contextualized for each individual. Since learners have already worked on the group activity it is easy for the learners to consult one another when working on their individual submission.
- At point "7" soft deadline for individual hand-in.
- At point "8" hard deadline for individual hand-in; peer assessment of individual hand-ins begins.
- Finally, point "9" has the soft deadline for peer assessment of individual hand-ins (hard deadline on Friday that proceeds). The tasks for each week are displayed on top of the platform every time you login. This is an important affordance of the NovoEd tool.

2.2 Learning Groups

In the first module there were auto-assigned learning groups of around 30 students. In the other modules the learning groups were self-formed and each group had at most 5 members. The activities created for module one were aimed at connecting students and getting familiar with the platform. This was good in building social connections in learning groups. A juggling activity was used in the first module. Learners were required to learn how to juggle and the submission required them to make video recording when they are juggling. This activity has a game concept which makes learners enjoy and get to know one another with ease. Since the juggling submission is seen by all learners, it helped in enforcing social connection. Activities were designed in such a way that each activity could build on another one within the module. For the activities to enhance group work, learners start with presenting individual answers to group activity. This is then followed by group discussion and hand-in. The learners are then given contextualized individual activity which is built on the previous group activity. Finally, there are at least three peer assessments on individual hand-ins. The final individual activity would be peer assessed using a pre-defined rubric which was developed by the course facilitators. In addition to the peer assessment, each assignment would get more feedback from students through comments. All the submitted activities are accessed by all the students in the course with possibility to comment and respond to comment. This encouraged interactions among learners online and student support.

2.3 Student Support and Peer Feedback

Student support is important for online learning courses. Forums were created on the platform to help in giving or receiving feedback from the students or facilitators. They were created in order to harness the experiences and knowledge from the community of participants. The student support ranged from technical to subject matter. This was developed with the aim of allowing feedback to come from the students themselves given the student numbers in the MOOC. This fits well with the growing student numbers in higher education.

Peer feedback was encouraged since all the submissions were accessed by the students in the MOOC. This allowed learners opportunity to give peer feedback through comments. Each submission received at least one feedback.

2.4 Differences in the MOOC

Most of the content of the course were the same. However, there was an emphasis on participation in the announcement for the MOOC of 2016. The announced placed on the platform clearly stated that “this is not a usual MOOC, because it is designed for active students. You have to pay for taking it by putting in at least 10 h of your time each week. The course features only a few videos, and the learning outcome is achieved by working on the tasks”. This is perceived to have played a big role in improving the course. In this course deadlines were changed from hard to soft. This seemed to have had a good impact on the learner's participation in the course. There was also flexibility on limits of the group size. In the 2015 MOOC there was fixed limit of five (5) members per group. However, in 2016 MOOC limits of Group size were changed to seven (7) members.

2.5 Methods

This paper is based on a comparative analysis of the course for 2015 and 2016. Qualitative and quantitative methods were used in collecting data and analysis. This helped in data triangulation. Two course surveys that is mid-term and course-end were run. These surveys were responded to by learners on the two MOOC courses. Mid-term survey had 27 respondents for 2015 and 36 respondents for the 2016. Course-end survey had 61 respondents for 2015 and 66 respondents for 2016. Observation was done on two online learning groups. The interactions on the forums were also used in the analysis.

3 Findings and Discussions

The course design helped in engaging students to participate with the course literature. At the end 1.44% of the students received statements of accomplishment in the first MOOC course and 5.04% of the students received statements of accomplishment in the second MOOC course. The findings are presented in the following subsections: course organization, learning groups and activities, learning group motivation, learning group interaction, learning groups peer-feedback and peer-assessment, and learning group collaboration tools.

3.1 Course Organization

This subsection describes the course organization. The organization determines the success and interactions of the learning group. Mayende et al. (2015), established that peer based assessment organization increased interaction and learning among group members. The course organization which puts emphasis on learning group is shown in Fig. 1. Initially, the students within the groups would submit individual work for the group activity. This helps to initiate the learners to learning group activity and each learner to contribute to the learning group discussion. The points of disagreement from individual viewpoints increased the learners' meaningfully learning. An individual submission is open to the entire class to give feedback which helps in the interaction and learning processes.

The individual answer to the group activity helps in the learning group discussions/processes. The students discuss/find solution for group activity online either synchronously or asynchronously. Once the group answer has been arrived at it is submitted/handed-in. However, group hand-in is accessed by all the students on the MOOC with affordances of peer feedback. The students are encouraged to give feedback to other group submission. After submission of the group work, the students work on the

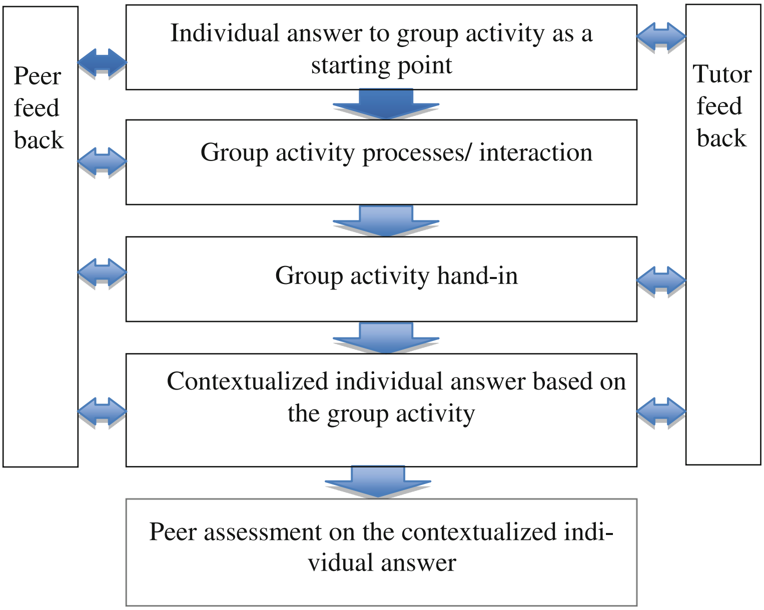

Fig. 1. Course organization

contextualized individual answer which is based on the group activity. The students are encouraged to consult with group members when working on this individual answer. Then the submission is peer assessed by at least three students using the rubric developed by the facilitators of the MOOC. This course organization made group formations very easy and encouraged interaction among students.

The students were asked to reveal their perception about the course organization by asking the participants to indicate their levels of agreement to the statements regarding course organization. Table 2 below indicates the percentage agreement with the statements for the MOOC of 2015 and 2016.

In both MOOCs the students perceived the courses to be well structured, activities to be well organized and assessment rubrics to be very clear. This is important in ensuring

Table 2. Course organisation

Statements	2015	2016
The course is well structured	93%	83%
The activities are well organized	86%	86%
The assessment rubrics are clear	89%	89%
The quizzes support my learning	43%	97%
I would need to be on campus to study this course efficiently	32%	17%
I believe that forum discussions are essential for this course	46%	69%
Cafeteria forum helps me get to know members of the group	39%	61%
I am achieving my learning expectations	11%	89%

that online courses in higher education are successful. This is in agreement with our earlier study which indicates that a well-designed detailed course guide can lead to an effective online learning group (Mayende et al. 2015). The respondent's perceived quizzes to support learning in the 2016 MOOC as shown in the Table 2. This might be one of the reasons for the difference in the completion rate. The quizzes were designed with aim of helping learners understand the theories of the course. This indicates that the 2016 MOOC benefited more in the area and the other MOOC missed out. Generally, students in both MOOCs did not agree that they needed to be at campus to study this course efficiently. This is in agreement with already distance learning programmes which are offered at the same competence level. Participants revealed the importance of forums; 46% believed that forum discussions were essential in the course in 2015 and 69% in 2016; 39% agreed that cafeteria forums helped in getting to know the members of the group in 2015 and 61% in 2016. This indicates that there was more interaction in the forums in 2016 than in 2015 which would be another cause for the better completion rate in 2016. The learners also perceived that they achieved their learning expectations in 2016. This could be another reason for better completion rate for the course.

Learners revealed that the following teaching resource contributed to learning output as shown in the percentages in Table 3 below.

Table 3. Teaching resources

Statements	2015	2016
Learning videos	87%	82%
Story videos	71%	77%
Group challenges	56%	70%
Individual challenges	84%	86%
Success wiki	76%	80%
Peer evaluation done by students	52%	67%
Peer evaluation received by students	46%	62%
Forum discussion	41%	53%

We can see differences in group challenges, peer evaluation done by students and peer evaluation received with advantage skewed towards the MOOC of 2016. There is still to do more to boost group assignment's contribution to the learning so that more completion rates can be achieved. This can be done by the facilitators increasing on the feedback they give. When asked about the effectiveness of the learning groups 44% felt that it was 70% and above effective, 40% felt that it was 40% – 60% effective, 16% felt it was below 40% effective. The organization of course organization played a big role in the effectiveness of the learning groups. However, this should also be coupled with appropriate online learning groups and activities.

3.2 Learning Groups and Activities

The group activity is important in ensuring success and interactions of a learning group. A well-structured course can help make the group activity easy to execute.

The students were asked to reveal their perception regarding activities and learning groups. The participants were asked to indicate their level of agreement to the statements regarding activities and learning groups. Table 3 below indicates the percentage agreement with the statements on both MOOCs.

In both MOOCs students agreed that activities were clearly described with enough time allocation to the activities. This is important for online courses since these types of learners are doing many things in additional to studying. These are typical of distance learning students who are working and studying at the same time, which is common for the learners of today. If the activities are not clearly described this can lead to higher dropout rate especially for the online courses. This can also apply in higher education. It is important for online courses in higher education to ensure that the activities are clearly described with enough time allocation to the activities. The students were in agreement that the activities were connected to the overall course objective. With activities which are connected to the course objective, this will help to ensure that the learning outcomes are met. The students also felt that the course resources helped them in doing the group activity. Having course resources that are connected to group activity will go a long away in ensuring effectiveness of the learning group. Though having indicative course resources to do group activity is important, students should be allowed to be innovative and bring in new course resources when doing their assignments. This is possible with an online learning community. As shown in the Table 3, students of the MOOC of 2016 agreed to the roles and processes for problem solving more than the MOOC of 2015. This shows that there are better group dynamics in 2016 as compared to 2015 which can be one of the reason for the better completion rate in 2016 than 2015. For purposes of effective social group connection it is important for the group members to agree on the roles and processes within the group. Higher education should encourage learners to agree on their roles in order to have effective learning groups. Results also revealed that only a few participants in both MOOCs were frustrated with one or more group members and the group size was big and distracted the group. The group size of five (5) members can bring about effective interaction and group deliberations. Since group size was five that is the reason they felt that they were not distracted by the group size.

Students were also asked their perception of their learning groups. Table 4 shows the percentage of respondents who perceived the statements to be true about their learning groups in both MOOCs.

Table 4. Learning groups and activities

Statement	2015	2016
The activities are clearly described with enough time allocated to the activities	71%	75%
The activities are connected to the overall course objective	75%	89%
The course resources help me in doing the group activities	68%	83%
Members agree about roles and processes for problem solving	43%	72%
I am frustrated with one or more of my team members	29%	14%
Group size is too big and distracts the group	14%	11%

On average 55% of respondents agreed with positive statement about learning groups in 2016 and 40% in 2015. The statements included the following “Our team members were supportive and encouraging each other”, “I received positive feedback from my peers”. “Our team members respected my opinions”. The above statements indicated high percentage of agreement. These help in motivating and sustaining interaction within learning groups. However, students never reached levels of sharing jokes during their group discussion which is indication that the groups had not got to high levels of group dynamics as indicated in the Tuckman five stage model. Learners shared jokes in the 2016 MOOC compared to the 2015 which could be a reason for better completion rate. These elements are very important aspects of effective online learning groups in helping to motivate members. In higher education it should be encouraged to let students know that support, encouragement, positive feedback, respecting opinions from group members are important aspects for effective online learning groups (Table 5).

Table 5. Learning groups

Statement	2015	2016
Our team was effective	41%	62%
Our team members were supportive and encouraging each other	46%	65%
I received positive feedback from my peers	48%	68%
We shared jokes in my team	13%	21%
I was active in my team	51%	56%
Our team members respected my opinions	41%	55%

3.3 Learning Group Motivation

Motivation is important for sustainable online learning groups. Motivation is not one-off event but a continuous process throughout the learning group life. Students agreed that they were motivated by their peer’s interaction within the group. One of the students said “The more you get quick feedback on your submissions definitely the more you get motivated”. Eighty six percent (86%) were in agreement with the above statements in 2016 and 50% in 2015. For effective online learning groups in higher education group members should be motivated within the group by their peers and facilitators. Gallimore and Tharp (1990), suggested that positive feedback encourages learner participation.

On average 56% of the respondents for 2016 MOOC and 32% of the respondents for 2015 MOOC were motivated by the following aspects: positive feedback from team members, level of commitment from team mates, not to let down the learning group and encouragement to express individual concerns. This is in agreement with educational psychologists who believe that positive rewards play a big role in encouraging participation and interaction (Gallimore and Tharp 1990). Students were given guidelines on how to respond within the groups e.g. encouragement to give positive feedback. Guidelines on how students should behave are very important to the motivation of learners in online learning groups. This is equally important for higher education. Therefore, encouraging students to give positive feedback will help in motivating the learning group members. When interactions or commitment within the group are high, the other students will fear to let down their team members. Motivation is vital in sustaining interactions and learning in learning groups.

3.4 Learning Group Interactions

Student interactions are important in increasing learning in learning groups (Anderson 2003). Interactions are encouraged through course organization. The organization allowed open feedback on all submissions by all the students. The students received feedback through comments on their submissions. Though the cafeteria forum was meant for social discussions, it generated a lot of content-related interactions. Students interacted with classmates using questioning which generated a lot of discussions. Questioning that provoke other learners to think more or read content can help in assisting learning (Gallimore and Tharp 1990). Some of the examples picked from the forums that used questioning:- "I agree with your thoughts on being successful in learning regardless of the type - good or bad - of experience. Do you think that almost everyone wants to be successful in learning?" and "Not achieving/finishing a task is not always failure; sometimes it is success delayed. What do you think?" This encouraged many students to interact with classmates through these forums.

There were also forums created with the aim of supporting students on both technical problems and content. These forums equally received a lot of posts and comments which helped the students in getting support from other students and tutors. Because forum interactions are open to all students and tutors, the interactions were quality assured since corrections are made in case some person gives wrong comment.

Students felt that they are able to improve their ability to express thoughts online. In 2016, 89% responded in agreement that they were able to improve their ability to express themselves while there was 50% for 2015 MOOC. This shows that the students started finding interaction interesting and easy which could be an indication difference in completion rate.

Students were asked their perception of their interactions in learning groups. The Table 6 shows the percentage of respondents who perceived the statement to be true about their interactions in the learning groups.

The statements were required to understand the level of interactions in the groups based on Bloom's taxonomy. The interaction questions were based on the verbs remember, understand and analyze. Remember is based on recalling facts and basic concepts, understand is based on explaining ideas or concepts and analyze is based on

Table 6. Learning group motivation

Statements	2015	2016
I was motivated by the positive feedback from my team members	46%	62%
I was motivated not to let down my team	33%	53%
I was motivated because I was encouraged to express my concerns	23%	42%
I was motivated by the level of commitment from my team mates	26%	65%

drawing connections among ideas. On average 52% of the respondents in 2016 MOOC perceived their interaction to lower levels of remembering and understanding while 37% of respondents in 2015 MOOC. This can be improved by facilitators getting involved in the interaction to provoke for higher level cognitive interactions. However, it is not easy for MOOCs given that the numbers of students are usually very high. This can be done in higher education by the facilitators provoking students during their interactions in the groups. Respondents also revealed that they used personal experiences when discussing the course concepts. This helps learners get new knowledge from authentic examples from more knowledge peers. The interaction was due to the design of the course which allowed peer feedback and assessment.

3.5 Learning Group Peer Feedback and Assessment

Peer feedback played a big role in ensuring interactions with the course platform. Since all the submissions were assessed through the platform the students interacted and helped peers get more feedback on their submissions.

Peer assessment was done on final contextualized individual answer. The facilitators developed rubrics that assisted the students to asses other student's submissions. It was emphasized that each student should give assessment to at least three students. The peer assessment was viewed by the students so that they see how they have been assessed and help them understand better the concepts they had missed out. Learning happens both during provision of peer assessment and receiving peer assessment. Forty percent (40%) of the respondents felt that they were able to get new knowledge through peer assessment for 2015 MOOC and 68% for the 2016 MOOC.

3.6 Learning Group Collaboration Tools

This course was run on NovoEd platform but with flexibility to allow learners use other collaborative tools. Though there are so many technologies that can be used for collaboration student revealed that they used the following tools as shown in Tables 7 and 8.

Table 7. Learning group interaction

Statement	2015	2016
The group interactions required me to remember the course content	39%	45%
The group interactions required me to understand the course content	34%	58%
The group interactions required me to analyse the course content	33%	48%
I was able to use personal experience when discussing the course concepts	41%	61%

Mostly, the NovoEd tool was used in the collaboration of the learning groups. However, other collaboration tools were also seldom used as indicated in the percentages in the Table 7.

Table 8. Collaboration tools

Tool	2015	2016
NovoEd	46%	51%
Social Media (Facebook, Twitter, LinkedIn, etc.)	5%	8%
Email	11%	14%
Online Conference (Skype, webinar)	9%	5%
Blogs (Discussion forum,)	5%	2%
Online shared workspace (Google drive, Dropbox, wiki)	14%	17%
Telephone	2%	3%
Others	7%	2%

Eighty two percent (82%) of the respondents felt that they sometimes got lost in the platform and failed to find what they wanted in the 2015 MOOC while 31% for 2016 MOOC. This shows that students in the second MOOC were more comfortable using the platform than the first MOOC. This has a significant bearing on the effectiveness of a learning group. Likewise 89% of the respondents in 2015 MOOC also felt that it was difficult for them to learn how to use NovoEd unlike 11% for 2016 MOOC. This might have been because many of the students who attended 2016 also come back from the 2015 MOOC. This makes them have fewer challenges using the platform. Fewer respondents 14% felt that they were comfortable seeking help via the forum while the 2016 MOOC had 75% who would get help from the forum (Table 9).

Table 9. Effective collaboration tools

Statement	2015	2016
The group members provided technical support during group work	30%	36%
Our team has used collaborative tools outside NovoEd	13%	30%
In team interaction, it was sometimes frustrating to use technology	30%	20%
NovoEd was an effective tool for team work	46%	62%
Google hangout was an effective tool for team work	20%	21%

About Tools support as shown in the table above – 29% for the 2015 MOOC and 36% for the 2016 MOOC, provided technical support during group work, 13% for the 2015 MOOC and 30% for the 2016 MOOC, used collaborative tools outside NovoEd, 29% for the 2015 MOOC and 20% for the 2016 MOOC, during team interaction, were sometimes frustrated to use technology. 44% for the 2015 MOOC and 62% for the 2016 MOOC, felt that NovoEd was an effective tool for team work, 19% for the 2015 MOOC and 21% for the 2016 MOOC, felt that Google hangout was an effective tool for team work. Tool usability is important for the success of online learning group.

4 Conclusion

We conclude that the course organization structured for online learning groups has the potential to increase individual participation in groups. As such the course organization can be an effective mechanism for facilitating online learning group activities in higher education. The course organization removes the known burden of supporting large student numbers reminiscent of MOOCs as it increases interaction among participants. The course organization help in providing clear sets of activities well aligned to the learning goals and resources. The increased feedback mechanism within the course organization is good pre-cursor to participation motivation which leads to low levels of dropout. Therefore, for an effective online learning group the following must be emphasized; well-structured course organization that supports group work, well-structured group activities that have the affordances of online collaboration and connected to the goals of the course, guiding students on how to motivate others through feedback and questioning, encouraging interaction within a learning group, learning group tool usability and features that have the affordance of group processes and online technical support.

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Project-Based Learning

An Inclusive Musical Mechatronics Course

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Abstract. This paper presents the design of a novel course in mechatronics, based on a project-based learning pedagogical philosophy that uses music as the theme to introduce to a diverse range of learners, the essential concepts of mechatronic practice. The course is designed at a post-graduate level and is targeted at international students who are likely to have a diverse range of background knowledge and potentially even a greater diversity in practical experience. The course builds upon our knowledge and capability in the construction or instrumentation of musical devices and cumulates in the construction of a new mechatronic chordophone and the preparation of an IEEE conference paper submission.

Keywords: Musical mechatronics · Project based learning

1 Introduction

An opportunity and a challenge has recently presented itself. Our University was successful in a collaborative bid for one of New Zealand's three recently Government funded ICT Graduate Schools. This bid was competitive with strong submissions from all of New Zealand's leading ICT tertiary providers. The purpose of these Graduate Schools is to increase the number of ICT skilled students entering the New Zealand workforce given that local industries are unable to fill their current ICT vacancies. The NZ Government is prepared to fund the establishment and initial running costs of such a centre up to approximately $10m (USD). Our bid was chosen over our competitors on the basis of the innovative degree programmes we proposed.

This paper details the construction of a novel mechatronics course that will be accommodated both within our new Masters of Engineering Practice (MEP) degree – designed for international students wishing to enter our ICT Graduate School, and also within our Bachelor of Engineering (Hons) (BE[Hons]) degree that is dominated by domestic students. There are multiple challenges in designing such a course:

- It must accommodate students with a wide variety of prior technical experience
- It must accommodate students with a variety of different learning styles
- It must provide advanced level instruction and development of mechatronic skills
- It should enthuse and motivate students, and ideally become a flagship course to promote both the MEP and BE (Hons) degrees.

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We choose to engage a Project Based Learning (PBL) pedagogy to realise these goals.

2 Background Context

Taught masters course proliferate internationally, with a huge number of universities offering some form of them. However, very often such programmes only emphasise the acquisition of technical knowledge, which can have little industry relevance, and can do little to develop independent or group project skills. The NZ Government was very clear in its aspirations for the ICT Graduate School in that it had to be industry focused, with the goal of addressing the ICT skills deficit faced by NZ employers. Our Faculty approached this problem from both a domestic and an international student framework. For international students we created the Masters of Engineering Practice (MEP) degree.

The MEP is a 180 point programme, delivered over three trimesters or 12 months. It starts in November to better align with Northern Hemisphere student demand (in New Zealand, the domestic teaching year starts in March). Unlike traditional taught masters programmes, ours specifically develops the skills required by employers:

- High quality English technical communication skills (written and oral).
- Ability to work independently.
- Ability to work in group environments.
- High level technical capability.
- Relevant work experience.

The first trimester of the programme comprises 2 technical courses, a course on Research and Communication, and a course on Individual Engineering Practice to develop individual research and project skills. Trimester 2 comprises another 2 technical courses, and a Group Engineering Project. Trimester 3 is a paid internship in a NZ company where a complex problem is undertaken under both industry and academic supervision. The MEP is currently offered in two streams, mechatronics and software engineering. A cyber-security stream will be introduced in 2017. Further details of this course can be found in [1]. The Musical Mechatronics Course, ECEN427, is created as a core course in the MEP, but will also be offered to our final year BE (Hons) students (in a different trimester). Note that the final year courses of a BE (hons) degree are at a masters level, hence facilitating this dual offering.

3 Why Project Based Learning?

It has been widely publicized that traditional methods of tertiary education in engineering are failing to deliver enough engineering graduates. Mills and Treagast [2] summarized the critical issues facing traditional engineering education in the following six points:

1. Engineering curricula are too focused on engineering science and technical courses without providing sufficient integration of these topics or relating them to industrial practice. Programs are content driven.
2. Current programs do not provide sufficient design experiences to students.
3. Graduates still lack communication skills and teamwork experience and programs need to incorporate more opportunities for students to develop these.
4. Programs need to develop more awareness amongst students of the social, environmental, economic and legal issues that are part of the reality of modern engineering practice.
5. Existing faculty lack practical experience, hence are not able to adequately relate theory to practice or provide design experiences. Present promotion systems reward research activities and not practical experience or teaching expertise.
6. The existing teaching and learning strategies or culture in engineering programs is outdated and needs to become more student-centred.

Project based learning is an alternative which has received some success in engineering education through its use of active learning and student centred pedagogical approach [3, 4].

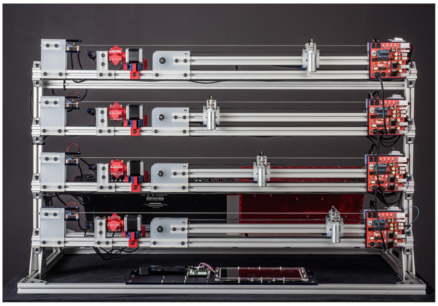
PBL acts to enhance student participation in the learning process and increases the students' ability to communicate and develop critical thinking. It also importantly provides a learning environment that is applicable to a wide range of student learning styles making it ideal as a means of teaching groups of diverse students, such as international students, students from different cultural backgrounds and students with differing academic levels. PBL has also shown itself to be extremely good at increasing the participation of female students [5–9].

4 Music Inspiration

The authors of this paper recently reported on the success of a sophomore engineering course that uses music and sound to motivate a basic understanding of sensors, actuators, data acquisition, microcontrollers and CAD/CAM techniques. The course was highly successful in motivating and engaging students, and the emphasis on creativity and innovation yielded projects well beyond the expectations of the Faculty [10].

Such a use of music or audio to inspire and provide context to learning is not in itself new. For example, Misra, Blank, and Kumar use a musical paradigm focused on sound synthesis techniques and computer-generated music in teaching introductory computing [11]. Further examples can be found in [12–14].

Our University is extremely well placed to engage with a musical motivation. In collaboration with the New Zealand School of Music and the California Institute of the Arts (regularly ranked as one of the top fine arts Colleges in the USA), we have established a world-ranked research centre in the field of the intersection of sonic art and engineering. Successful previous projects include the mechanical bass guitar, MechBass [15] (Fig. 1 left), that now has over 700,000 YouTube hits (for example [16]), the modular 6 string guitar Swivel 2 [17], the integrated mechatronic guitar StrumBot [18], and a number of other mechatronic instruments detailed in [19, 20].



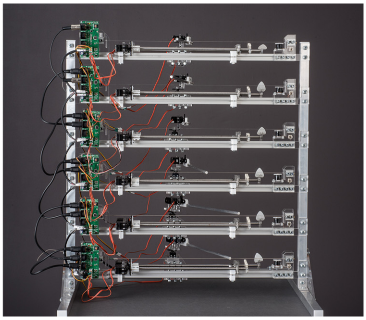


Fig. 1. MechBass – a four string robotic bass-guitar (left). Swivel 2 – a six stringed modular robotic guitar (right)

This provides us with the expertise to successfully utilize PBL in the development and delivery of a mechatronics music course as well as being able to motivate the students by an inspirational demonstration of some of these developed devices.

5 Specific Learning Objectives

A criticism often levelled at PBL-type courses is that the students "don't know what they don't know". In other words, they may have a complete ignorance of a particular technique or knowledge and require some direction in order to obtain such information or to develop the required skill. Poorly designed PBL courses can leave such issues entirely up to the students, meaning that they can miss what "traditional" courses would deem to be essential.

We seek to mitigate this by providing the students with an explicit list of core learning objectives in the course. This also ensures that the instructors can ensure that each student is aware of these expectations and can appropriately guide them. For this course, our learning objectives (phrased as questions) are:

- How can we effectively conduct a literature review in order to help in the development of a new mechatronic assembly?
- What are important audio "features" in different contexts? What kind of feature extraction systems are appropriate in a mechatronics context? How can we create a feature extraction toolchain?
- What actuator parameters are important to consider in this context, and how do different requirements lead to different component choices?
- What types of actuators may be used in mechatronics? What actuator criteria should be taken into consideration when developing and evaluating a mechatronic subsystem?
- How can we integrate multiple mechatronic subsystems? How does the integration of multiple subsystems affect design decisions?
- How do we choose the most important design criteria, when there are multiple possible development avenues? Further, how may this be assessed?

- How can we utilise a CAD/CAM workflow approach to aid a mechatronic project development?
- How can we benefit from an iterative design flow in improving a mechatronic system?

This list comprises both knowledge and skill set considerations. The next section outlines how we divide the course into two components – the first primarily formative, the feedback from which informs the second, and more difficult component.

6 Formative and Summative Assessment

The course is designed to guide students working in groups, through the design issues of the construction of a major mechatronic musical device. For the first iteration of the course, we are choosing the chordophone as our device of preference. The reasons for this are both pragmatic and inspirational. Viewing MechBass with over 700,000 YouTube views inspires the students to equal or better this achievement. Pragmatically, the chordophone provides us with the opportunity to discuss a range of relevant mechatronically relevant topics, including sensors, actuators, drivers, microcontrollers, data acquisition, CAD/CAM techniques, rapid prototyping (3D printing and laser cutting) and workshop skills in the creation of the chassis. There is also significant flexibility in terms of the design of the chordophones elements – there is no one best technique. However, crucially it also allows a division of the course into two components, the first is a strongly formative learning exercise, and the second is a combination of formative and summative.

There are two critical components of a mechatronic chordophone, the strummer/picker and the pitch-shifter (which is also referred to as a fretting mechanism). Of these, the strummer (or picker) is the mechatronically simpler. There are a variety of techniques that we (and others) have employed to effect a strumming/picking device [21], including push-pull solenoids, stepper motors, servo motors, DC motors on a tilt to alter the attack strength on the string [15] and modified SCARA robot arms [18].

Our course therefore begins with the design of the strummer. It is our desire to not only develop mechatronic skills in our students but also to reinforce and shape their thinking as senior engineering students. So early in the course the students are required to prepare an individual literature review detailing previous work on strumming mechanisms, analysing and identifying strengths and/or short-comings of these previous approaches and consequently motivating their own designs. This literature review is only worth 5% of the course grade, but will be used later in the capstone assessment. We expect a variety of skills to be exhibited depending upon students' past experience with formal report writing, so the low assessment weighting is a reflection on the formative nature of such a review at this stage – all submissions will be individually edited and critiqued to help improve student performance.

The students are then guided through the development of their nominated strumming/picking mechanism. A group report must be produced that discusses the related works, methodology, evaluation of the system and conclusion. The working device must be demonstrated, and each member of the team must be involved in the presentation. Students must also produce an individual report that clearly identifies their contribution to the project, and every member of the group completes a peer-assessment form whereby they can express their (confidential) opinions on the performance of the other group members. The result of these reports, peer-evaluations and demonstration is a grade that comprises 20% of their final course mark.

Part 2 of the course requires the design of the far more complex pitch-shifter/fretter mechanism, and the chordophone chassis. The groups are changed to provide some heterogeneous mixture of project contributors. Again this project begins with the requirement for a formal literature review. This is a summative assessment – ample feedback was provided during Part I of the course, and is worth 10% of the final course grade.

The students are then guided in the PBL style, through the design and development of this pitch shifting device, the integration of this with the previously designed strummer/picker, and the design of a mechanically robust and aesthetically appropriate chassis. High achieving students would seek input from our School of Design Faculty.

Of course we need to be aware that failure in Part I of the course should not preclude success in Part II, so we have available some pre-built strumming devices should a group not have their own. This is a major project and it is too risky (in the authors' opinions) to not have an interim milestone. Therefore at the half-way point of the project, a group mark of 5% is awarded for the preparation of a progress report. There is no attempt to identify individual contributors at this stage.

The final report, demonstration and presentation follows the same format as for the strummer/picking mechanism, and individual grades are awarded. This comprises 50% of the final grade.

The final 10% of the assessment is a group mark and requires the production of an appropriately formatted conference submission paper. This will be submitted to an appropriate forum, perhaps NIME or other relevant conference. Papers from all groups will be submitted although of course it will not be possible to know of paper acceptance in advance of awarding a grade for the paper. The authors' experience in submitting and reviewing such papers themselves must suffice.

7 Managing Workload

The primary author of this paper has developed, coordinated, and delivered a number of mechatronic papers, with varying levels of emphasis on skills and knowledge content. Problems have occurred in some of these courses specifically those that use "open-ended" assessment projects.

Such open-ended projects can often consume far more student time than was originally expected. Whilst one approach is to impose formal constraints on the expected student output, the authors feel that this unduly constrains the students' creativity, problem solving innovation and the development of life-learning habits where they take control of the final quality of the project. Nevertheless, in our degree programme, students are expected to undertake four courses per trimester, and an on-going problem is students becoming so motivated and engrossed in the mechatronic courses that they do not put sufficient time into the others.

The authors strongly believe that such motivation is an excellent outcome, but if not handled carefully, this additional workload and the resulting lack of work-lifestyle balance leads to increasingly levels of stress, degraded well-being and potentially poor performance in other required (but perhaps less motivating) courses. Our compromise for this course is to clearly define what our expectations are – detailing in writing to the students what a C (minimum pass grade) output would look like, what a B grade would require, and what must be achieved for the A. This gives the students a priori knowledge of the time implications and assist them to balance their overall workload.

8 Extension Work

We are prepared for highly capable groups in terms of potential extensions to the project if necessary. The performance of mechatronic chordophones is directly related to the placement of the pitch-shifting mechanisms. If these can be intelligently placed, so that the movement to the next incoming note is minimal, then the device can play at a far faster rate. To optimize for this requires a level of artificial intelligence. The same note can be played on different strings with different positioning of the fretter. Pre-recorded material can be pre-processed to determine such optimal positionings through a non-trivial algorithm. The students could potentially investigate several forms of artificial intelligence (AI) algorithms to help determine these. Testing and evaluation of such pre-recordings is mostly straight-forward.

Of course the students might be aware of this and design a system that has a series of solenoids in place that require no translational movement – an activation of the solenoid will clamp the string at that pre-determined position. We would not prevent the students selecting such an option, and this does completely mitigate the issues noted above, but the limitations of such strategies are well known in the music field, so the students would not (for example) be able to play Eastern (i.e. non-Western defined fretted positions) music, and a range of musical effects such as (for example) sliding movements would not be possible.

An alternative to the software intensive AI algorithm development is the creation of an electronic effects box that emulates the range of sounds available to professional guitar players. There are several effects that could be implemented depending upon the student skill and time available.

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An Integrated Project for Freshmen Students in a Software Engineering Education

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Abstract. Defining an integrated project for freshmen students in software engineering was a challenge but we were able to define one that includes the following disciplines: (1) Programming, (2) Multimedia, (3) English, (4) Embedded System and (5) Mathematics. The project respects also the Conceive, Design, Implement and Operate steps with professionals and parents participation. Despite the good results, we faced several other challenges, especially with teams problems and how to make a proper assessment.

Keywords: Freshmen students · Software engineering · Project based learning · CDIO

1 Introduction

After a period of discussion and reflection between teachers and the school administration staff, ESPRIT has decided to adopt the active learning approach. Since we have adopted a Problem Based Learning approach in the programming course during the first semester [1] and due to the encouraging results, teachers proposed to continue using the new approach during the second semester and we defined a Project-Based Learning that fills with CDIO steps.

For our freshmen students, the only programming language they know at the end of the first semester is C language. Traditionally we ask them for little projects that runs in the console mode, an MS-Dos like environment, and that never motivated them. In our case, the subject was to develop a video game. In the AY 2014–2015, a study was conducted to analyses the project results. In this paper, we will describe our project, the results of the study and recommendations.

2 General Background

Many researches proved that classic lecture dont have enough impact in the learning process for students and lacks soft skills acquisition. These soft skills are

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necessary in the future job for any students and especially engineering students [11,12]. Using Active Learning approach is a possible solution to help students to develop most of needed soft skills in industry. Thats why school administration accepted teachers request to use active learning in general and added the project that we are describing in this paper.

A delegates from ESPRIT visited Aalborg University in 2012 to have a better idea about PBL: what it is? How it works? How to implement it? The PBL model as it is practiced in Aalborg University is a project. Students have each semester one project with 15 credits and three lecture each with 5 credits [6]. The project that was designed and described in this paper respects the generic such as: Inter-disciplinary learning, Activity-based learning, Group-based learning and Experience learning [3,4].

In the same year, after visiting Telecom Bretagne institute, we discovered the CDIO initiative [2]. CDIO stands for: Conceive, Design, Implement and Operate. This 4 phases is present in most engineering real world projects. The CDIO initiative recommends that engineering students should applicate these 4 steps in their university projects to be quickly operational in industry when they graduate. Since CDIO and PBL can be complementary [5,6], teachers adapted the described project to respect the 4 CDIO phases.

3 Project Description

The "Projet 1A" is an integrated project that includes the following components: (1) Multimedia and Communication, (2) Procedural C Programming (3) Mathematics & basic physics and (4) Electronics.

Students work on this project during 14 weeks. Each group has a weekly meeting with tutors. Project phases are grouped in the Fig. 1. We ask students to choose their own team. Each team is composed of 4 to 6 members. Many hard skills is targeted in the project such as: Linux, gcc compiler, gdb debugger, svn source code managing, doxygen for project documentation and Arduino embedded systems.

During the Conceive phase, tutors ask the group to imagine a 2D video game. The group discusses ideas in a brainstorming session. At the end of this first phase, a game story that includes some original characters and levels has to be validated with tutors.

After fixing the global idea of the team 2D Game, they have to make the Design and create the game characters, background and other stuffs by drawing them by hand and finally using some graphical tools like Gimp or Adobe Photoshop/illustrator.

This first phase is done in an amount of one month. In parallel, students prepare the whole environment for the implementation of the game with the C language. They must install a GNU/Linux operating system, a friendly and easy C library like libSDL [7] and start developing the menu of their games.

The second Design phase is launched during the second month of the project. Each team must do some global and specific organizational chart, in consequence they prepare some global menus interfaces such as the game menu and the global Game loop. Also, they prepare the skeleton code containing modules (.h/.c) grouped by entities or objects inspired from theirs characters and entities inside their game story. The Design phase is a mixture between the Top-Down and the Bottom-Up approach between Design and first steps in the Implement code source. Once header files are written and contain some structures and some functions declarations, coaches validate the tasks distribution between each team member and the Implement phase starts. During this phase we have a set of sprints with three weeks duration for each one of them. During these sprints, the group has to achieve a different part of the game. They also have to optimize some characters moving in the game using some physics and mathematical basic aspects like rectilinear motion uniformly accelerated/decelerated, curvilinear motion in a 2D plan, using vectors [8] or simple collision detection between two entities [9].

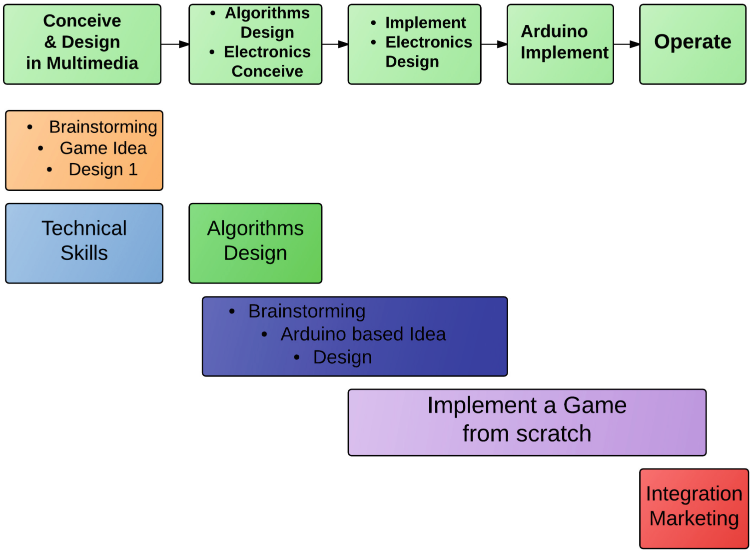

Fig. 1. Project phases

In Parallel to the procedural Implementation of their game, we begin to work on the Conceive and Design phase number 2. In this part, students will imagine and design how to use the embedded card Arduino with their games. Then the group has to implement their idea.

Finally, the game has to be tested and enhanced for a game play sensation and published using Facebook or by writing some blogs, this is the final Operate phase. During this phase each team has to prepare the trailer and the cinematic of the video game. They will also work on the graphic supports, the commercial presentation and a report.

At the beginning of the Conceive step, we organize an event called “GD2: Game Design Day”. During the GD2, professionals will introduce students to examples of real projects in the game field and give them advice to follow during the project. During this part, each team will imagine the story of the game and its characters. At the end, will prepare a specifications book. Students will be supervised in this step by multimedia and English teachers. Programming teachers validate the specifications by checking if it may lead to a good product at the end of the project period.

For the Operate phase, a second event is organized. We called it “GD3: Game Design & Development Day”. Each team will have a booth to present their work to the public. The same professionals are invited to select the best project. Multimedia and English teachers also take part in the Operate phase by mentoring students in the preparation of their commercial presentation, graphic visuals, and speech. Parents and family were dazzled by what these young first year students were able to achieve. Some photos from the GD3 event can be found here [10].

4 Results

4.1 Method

This study was conducted at the end of the second semester of the academic year 2014/2015. Quantitative measures were applied. A total of 235 first year students enrolled in 7-credit second semester module participated in the study. We asked the students to give us their feedback using a paper survey at the end of the academic year 2014/2015. The survey was anonymous. We also studied the scholar results of the learners.

4.2 Scholar Results

At the beginning of the project, the exact number of all the students was 235. At the end, 212 students did not abandon and succeeded to complete their projects. Project final grades are between 0 and 20. We classified the results obtained by students as follow:

- A: if the student grade is greater than 15.
- B: if the student grade is between 12 and 15.
- C: if the student grade is between 10 and 12.
- F: if the student grade is less than 10.

Students who did not validate their projects got F with a grade less than 10. In the final validation, each student will have an individual technical validation then a group validation.

In the Fig. 2. the scholar results statistics. 88.7% of students validated the project with A, B or C. In the final project validation, if a student doesnt pass

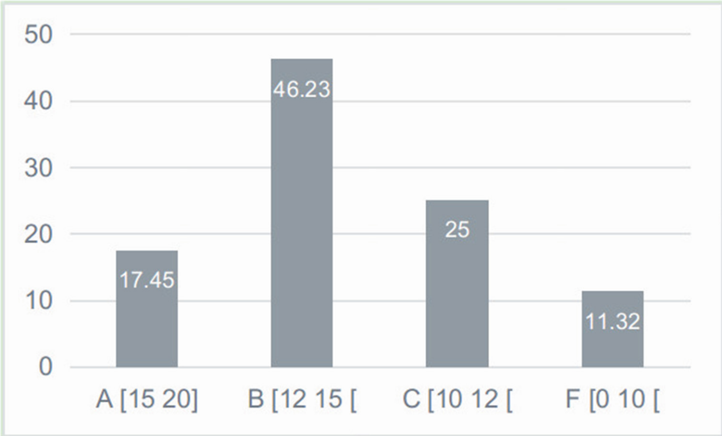

Fig. 2. Scholar results

the individual technical validation, he will got zero in the rest. These strict rules can explain a part of the 11.3% of failure.

A total of 63.7%, Fig. 2, validated the project with A or B which means that those students validated a large part of hard skills. Indeed, in the individual technical validation a student will have to answer questions about his/her work and will have to make some modifications in the game.

4.3 Survey Results

We asked the students to give their feedback using a paper survey. The survey was anonymous and was conducted at the end of the academic year 2014–2015. We received 196 responses from 235 registered students, which is 83.4% participation rate. 23 students abandoned the project from the beginning. If we consider students who continued until the final phase, the participation rate will be 92.45%. The survey was 17 questions long about teamwork and the overall satisfaction.

If we overview the Table 1. Teamwork, we can see that the average satisfaction on group work, answer to "Q9. Teamwork was a good experience", is almost 61%, 33.33% Agree + 27.69% fully agree. The percentage of students who are not at all satisfied with the teamwork experience are almost 12.5% which is approximately the same ratio of the students did not validate the project. It is also quite the same ratio who fully disagrees to the question "Q7. I feel confident working in teams".

48.71%, Q4, agree or fully agree that the contributions into the project was not balanced and 56.41%, Q5, agree or fully agree that the role of the leader is essential for the proper performance of the team's work.

Table 1. Teamwork

	Totally disagree	Disagree	Neutral/no opinion	Agree	Fully agree
Q1. We work better as a team	9, 79%	19, 07%	20,10%	40,21%	10, 82%
Q2. Our collaboration within the team was not up to my expectations	6, 63%	17, 86%	25,51%	34,69%	15, 31%
Q3. We communicate with each other effectively	9, 23%	21, 54%	28,21%	31,28%	9, 74%
Q4. I felt that we are not working as a team, the individual contributions are not balanced	9, 23%	16, 41%	25,64%	29,74%	18, 97%
Q5. The role of the leader is essential for the proper performance of the team's work	6, 15%	9, 23%	28,21%	30,26%	26, 15%
Q6. All my teammates have contributed to the achievement of the required work	16, 49%	18, 56%	21,13%	28,87%	14, 95%
Q7. I feel confident working in teams	12, 37%	12, 89%	28,35%	34,54%	11, 86%
Q8. I received useful and constructive comments of my teammates	2, 58%	5, 67%	20,10%	45,36%	26, 29%
Q9. Teamwork was a good experience	12, 31%	6, 15%	20,51%	33,33%	27, 69%

Table 2. Overall satisfaction

	Totally disagree	Disagree	Neutral/no opinion	Agree	Fully agree
Q10. Learning with PBL was a good experience	10, 33%	17, 93%	17,93%	41,85%	11, 96%
Q11. I feel I can improve my ability to work in teams	4, 89%	9, 24%	25,54%	40,76%	19, 57%
Q12. I am happy with my contribution in the work of my team	9, 24%	9, 24%	27,72%	35,33%	18, 48%
Q13. The quality of supervision was excellent	11, 96%	14, 67%	44,57%	23,37%	5, 43%
Q14. Our collaboration within teams could have been better	4, 35%	3, 80%	26,63%	39,13%	26, 09%
Q15. Overall I am satisfied with my experience during this semester	9, 78%	14, 13%	26,63%	33,15%	16, 30%
Q16. I'll do better next semester	2, 19%	4, 37%	25,68%	26,23%	41, 53%
Q17. I want to go back to the classic teaching method	19, 57%	14, 13%	36,41%	19,02%	10, 87%

Only 8.25% disagree or totally disagree with the statement in Q8 "I received useful and constructive comments of my teammates". This demonstrates that peer learning worked well in this case.

In the Table 2. Overall Satisfaction, you can see the questions about the overall satisfaction. The ratio of students who are satisfied with their overall experience, Q15, is 54%. About 30% agree or fully agree to request to go back to the classic teaching method, Q17. Only 6.56%, Q16, didn't think they could do better next time. 14.13% said they can't improve their ability to work in teams, Q11, and 65.22% agreed or fully agreed that the collaboration within teams could have been better, Q14.

For the quality of the supervision, Q13, 28.2% are satisfied, 26.63% not and 44.57% are neutral.

5 Conclusion

In this paper we have presented our integrated project for freshmen students in software engineering. The project was designed to adopt the CDIO approach. Multimedia, programming, English, Mathematics and Electronics was integrated into the project. We described the projects steps and how we tried to be more interactive with professionals throw "GD2: Game Design Day" and "GD3: Game Design & Development Day" events. We finished by analyzing the results scholar results and survey result.

Most of students was satisfied from this experience. They found it as a first project an excellent initiation for new students and a good experience that helped them to improve their personal and technical skills in design, programming and communication. This point is confirmed by answers to the Q9 in Table 1 and Q10, Q15 in Table 2.

In other hand, they highlight some problems with groups problems and communications in particular. This point is confirmed by answers to the Q2, Q3 and Q4 in Table 1.

One important advantages of PBL comparing to classic pedagogy is improving the ability of the learner in teamwork and peer to peer learning. This was confirmed by the survey answers to "Q1. We work better as a team", "Q8. I received useful and constructive comments of my teammates" and "Q9. Teamwork was a good experience". Even with some negative view, most of students feel they can improve abilities to work in teams, see answers of Q11 and Q16 in Table 2. This demonstrates that learners enriched their personal experience and soft skills and feel ready to avoid mistakes and apply good practices they learned about team work.

Despite the good results, we still have a lot of work to do with teachers so that they could be better coaches and have less students who drop down their projects or fail to validate it at the end of the semester. Less than 30% was satisfied from the quality of supervision, Q13 in Table 2. Also making a good assessment with group vs. individual validation is a challenge and we are trying to make it better each year. A work in progress paper will detail the assessment part in this project. We also have another work in progress paper about helping students learn why communication inside the group is important and how to communicate.

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Motivating Students with Bio-Fuel Student Engineering Competition Projects

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Abstract. College students often express concern regarding the impact of fossil fuels on the environment. Studying bio-fuels allows students to learn about both the fundamental principles of their discipline and broader issues such as understanding the impact of technology in a global, economic, environmental, and societal context. Further, students are motivated by competition. University engineering challenges can be used to intrinsically motivate these students. This paper describes the benefits and challenges for the students and University in participating in the SAE Clean Snowmobile Collegiate Design Series competition.

Keywords: Collegiate competitions · CDS · Clean Snowmobile Challenge

1 Introduction

Learning experiences are greatly improved when students are intrinsically motivated by the subject matter. According to Lepper [1], an intrinsically motivated student will undertake an activity "for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of accomplishment it evokes," while an extrinsically motivated student performs "in order to obtain some reward or avoid some punishment external to the activity itself." This naturally leads to different levels of effort in learning. For example, Lumsden [2] shows that intrinsically motivated students tend to employ strategies that demand more effort and that enable them to process information more deeply, while extrinsically oriented students are inclined to put forth minimal effort.

It is important for instructors to find educational activities that appeal to the intrinsic interest of their students. That is, find an activity or project that will be of natural interest to the students so that they will be motivated learn beyond the classroom.

2 Approach

College students often express concern regarding the impact of fossil fuels on the environment. Studying bio-fuels allows students to learn about both the fundamental principles of their discipline and broader issues such as understanding the impact of technology in a global, economic, environmental, and societal context.

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Further, students like all humans, are motivated by competition. Collegiate-level engineering design projects, where students from around the world directly compete, can also be used to intrinsically motivate these students.

This paper describes the benefits and challenges for the students and University in participating in the SAE Clean Snowmobile Collegiate Design Series competition. This competition combines the use of bio-fuels as a way to significantly improve exhaust emission and fuel economy along with the chance for students to compete against teams from other Universities.

Data is provided which describes the details of the competition, the number of teams involved and the international breakdown. Further, the results of student and alumni surveys are also presented to provide relevant feedback from the participants as to the value of these events.

3 Use of Bio-Fuels in Transportation

Bio-fuels provide many benefits over traditional non-renewable fuels. These benefits include reducing environmental impacts and, since bio-based fuels are produced from agricultural products, improved income for farmers.

In the U.S. bio-ethanol is usually produced through fermentation of corn. While bio-diesel is usually produced using soybeans. Of course, using traditional food sources such as corn to produce fuel presents students-and engineers-additional challenges such as the “food or fuel” public debate. This forces students to think beyond the technical challenges of using a different fuel to power an engine. Further, raising their interest level, and often provoking lively debates.

4 Development of the SAE Clean Snowmobile Challenge

In the contiguous U.S., snowmobiles are used largely for recreation; with only a fraction used in outdoor work. Recreational snowmobiling is often done in National Forests and Parks, such as Yellowstone National Park. Unfortunately, these pristine areas are subjected to the noise and exhaust emissions from these machines.

Due to the rising environmental concern pertaining to the noise and exhaust emissions of recreational snowmobiles, they have come under increased scrutiny by the U. S. federal government. As snowmobiles are used in the winter season, the environmental impacts are greater due to the cold air. The cold, dense ambient air will not disperse the exhaust emissions rapidly; this tends to trap the concentrated exhaust emissions leading to locally high concentrations of pollutants.

Considering the economic impact of this market, a ban on snowmobiling is not a feasible option. Currently, U.S. national Parks are operating under a temporary winter use plan that restricts the number of snowmobiles entering the parks per day. All snowmobiles are required to be Best Available Technology (BAT), which are the cleanest and quietest commercially available snowmobiles. Further, the U.S. Environmental Protection Agency (EPA) has issued limits on snowmobile emissions. The specific limits are shown in Table 1.

Table 1. U.S. exhaust emission standards for snowmobiles [3]

	Phase in	Emissions (g/kW-hr)		
Model year	(% of sales)	HC	HC + NOx	CO
2006	50	100	–	275
2007–2009	100	100	–	275
2010–2011	100	75	–	275
2012 & later	100	75	90	275
NPS BAT		15		120

This legislation has forced a rapid change upon manufacturers; and they have responded by further developing two-stroke technology and shifting to four-stroke engines in place of the typical two-stroke engines. While the two-stroke engine offers advantages in light weight and peak power output compared to four-stroke engines, the disadvantage is that it emits much higher levels of exhaust pollutants. The four-stroke engine is also quieter, and more fuel efficient when compared with an equivalent two-stroke engine. Nonetheless, the four-stroke engine size and weight disadvantage is a substantial challenge to overcome in a lightweight vehicle.

The Clean Snowmobile Challenge (CSC), which is part of the Collegiate Design Series of the Society of Automotive Engineers (SAE), was created to challenge students to reduce the environmental impact of snowmobiles while retaining the essential performance and cost limitations required to ensure a successful recreational market.

SAE Clean Snowmobile Challenge Structure and Goals

The SAE Clean Snowmobile Challenge (SAE CSC) is an annual international collegiate student design competition. The over-arching goals are to develop snowmobiles which emit the lowest exhaust and noise emissions, while achieving the greatest fuel efficiency. All while maintaining an acceptable level of performance and handling, and minimum cost increase since snowmobiles are used in recreational activities!

Competition rules require that students start with a commercially available snowmobile and then make extensive modifications to the engine and powertrain. To expand interest and to include more students, there are two classes of snowmobiles allowed in the competition: internal combustion engines (ICE), and electric powered snowmobiles. Snowmobiles in the ICE class must use an unknown blend of bio-ethanol and gasoline, or bio-diesel and conventional diesel fuel. This challenges the students to provide for flexible fuel usage-a real-world constraint.

The collegiate teams participating in the SAE Clean Snowmobile Challenge earn points for their performance in a multitude of events. Some competition events are static, where students present the business and design aspects of the project to judges drawn from a wide audience including engineers, snowmobile outfitters, business, and marketing professionals. Further, each team must write a complete technical paper using the format of SAE papers used at technical conferences and journals. Other events are dynamic, that is, the snowmobiles are driven and tested to ascertain the exhaust and noise emissions, fuel economy, and the performance such as acceleration, handling, and cold-startability. During the competition, students also use at least two different blends of fuel of an unknown composition. For example, the 2013 SAE CSC used an unknown bio-ethanol and gasoline blended fuel ranging from 40% to 75% ethanol for the dynamic events. The events and their maximum point values are shown in Table 2.

Table 2. Competition events and point structure 2013 SAE CSC [4]

Engineering design paper	100
Manufacturer suggested retail price	50
Laboratory emissions	300
Brake specific fuel consumption	50
In-service emissions	50
In-service fuel economy	50
Oral presentation	100
Fuel economy and endurance	200
Acceleration	50
Objective handling	50
Subjective handling	50
Cold start	50
Static display	50
Objective noise	150
Subjective noise	150
No-maintenance bonus	100

In order to make the event as realistic as is possible, many events are conducted and judged by practicing professionals from industry. For example, the Laboratory Emissions test is conducted by one of the major emissions equipment manufacturers and is conducted to U.S. Federal test specifications. In the subjective handling event, each snowmobile is driven by an independent member of a major recreational snowmobile volunteer organization. All Design papers are reviewed by an anonymous group of professional engineers from industry, universities, and the federal government.

5 SAE Collegiate Design Series Challenges and Demographics

The Clean Snowmobile Challenge is limited to fewer teams than some of the other Challenges due to the nature and level of the testing which is required. During the 2015 challenge, 21 teams from N. America and Europe competed, with team participation ranging from small private universities to large public universities.

However, this Challenge is just one of many different events for college students. These vehicle design challenges include race cars, off-road vehicles for summer and winter use, and airplanes. Competition goals vary from competition to competition. All of the competitions share a common vision to encourage students to work in teams to: Design, Build, Describe, and Compete using their own vehicles.

The CDS competitions have proven to be extremely popular with students all around the world. Figure 1, from 2010, shows that over 700 Universities from around the world competed in these competitions. Further, many of the events are fully subscribed. The popularity of these events leads them to sell out quickly. For example, the Formula SAE events typically sell out in under 30 min-despite entry fees (due at the time of reservation) in excess of $2000.

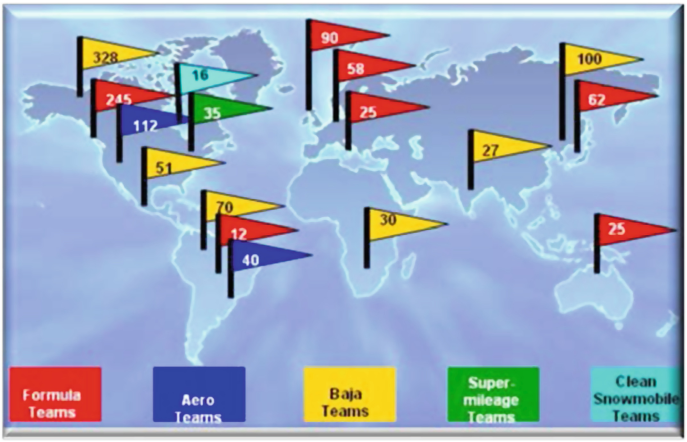

Fig. 1. Illustration of teams and locations of various competitions in 2010

Additionally, teams are choosing to compete outside of their geographic region. For example, almost half of the teams competing in the AeroDesign competition held in the U.S. are from outside North America. In fact, overall, about 15% of teams competing in U.S. venues are from outside N. America. Details regarding the fraction of teams competing in the United States venues from outside of North America are presented in Fig. 2.

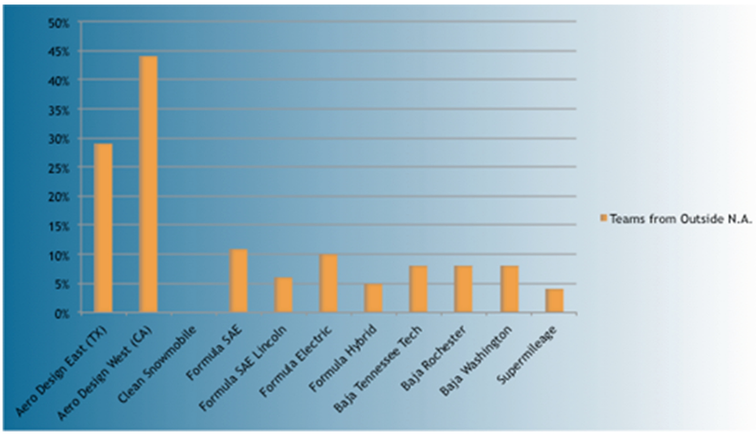

Fig. 2. Percentage of teams from outside of North America competing in the U.S. competitions

6 Results

Students are given the opportunity to apply principles they are learning in school to solve real engineering problems. Through this process they gain insight into the complexities involved when working within a diverse team, constrained by tight budgetary and time deadlines.

The students have also demonstrated the ability to produce vehicles which not only meet strict federal emissions standards, but actually exceed these standards. For example, during the 2007 CSC, the student snowmobile was tested for exhaust emissions, and compared both to a commercially available snowmobile, and to the 2012 U.S. EPA emissions standards. Figure 3 compares emissions results of the baseline snowmobile, the final student snowmobile, and the 2012 emissions standards.

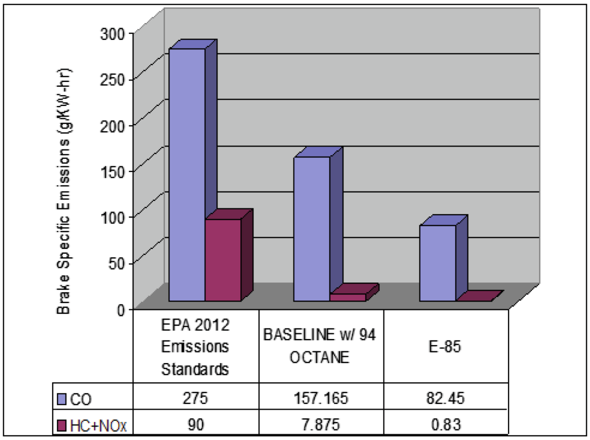

Fig. 3. Emissions comparison between 2012 EPA standard, baseline commercial control snowmobile, and 2007 university student CSC E-85 snowmobile.

As is seen, not only did the team significantly reduce emissions as compared with the control snowmobile, but they also significantly reduced the emissions as compared to the new EPA regulations set for enforcement in 2012. The snowmobile design and performance was published in a technical paper which was presented by the faculty advisor and one of the students at a professional society conference [5].

Student participants are also drawn into engineering professional organizations where they begin to learn to take an active role in their engineering profession. Student projects are often turned into research papers and presentations. This work is presented at professional engineering conferences located around the world including sessions held annually at the SAE Small Engine Technology Conference, SAE World Congress & Exposition, and other professional gatherings. In fact, enough students participate in these activities that entire technical sessions are annually devoted to their work.

Alumni Feedback

To evaluate the effectiveness of this approach in raising the motivation of students, a survey was developed and distributed to graduates from the previous six years, with degrees in either mechanical or electrical engineering. Of the 587 alumni that were emailed, 148 (25%) responded. A majority of the respondents (81%) identifying themselves as graduates of the mechanical engineering program.

The respondents were nearly evenly divided between alumni that had been student members of SAE (44%) and alumni that had not been student members (56%). Approximately a quarter of the responding alumni, indicated that they actively participated in SAE activities while they were students.

The participating alumni were asked about how their experiences with SAE activities affected their perception of the university, their perception of the education program, and the preparation for their careers. The responses to each question were similar.

A third of the alumni responded that their participation in these activities **greatly improved** their perception/preparation. While at least three-quarters of the respondents indicated that their perception/preparation was at least somewhat improved by their participation in these activities. This clearly indicates that these alumni valued the educational experience provided to them.

Anecdotal testimony as to the effectiveness of these experiences can be found in the responses of the young alumni to the following question:

"What was the best part of being an SAE student team member?"

- "It was a chance to teach my skills to others, or learn together. I got to be part of a team of peers and not part of a hierarchy (like at work)."
- "It was hands on. I actually got to use some of classroom material. It was an outlet to test my engineering and managing abilities."
- "I'm now a ride and handling development engineer because of the work I did while part of Mini Baja."
- "The hands-on experience (fabrication, CAE) was valuable in my engineering career after Kettering. Functioning on a dynamic team with an aggressive product development schedule better prepared us for the challenges of those in the automotive field. Lastly, many people in the automotive field were either involved with or are familiar with the SAE Motorsports programs. (For example, I work with many former members of FSAE teams…Kettering, LTU, Cornell, Texas A&M, U of M). I believe involvement in the program commands respect in the industry."

7 Conclusions

This paper has briefly described some of benefits for the students participating in real-world projects such as the SAE Clean Snowmobile Collegiate Design Series competition. These competitions appeal to students on several levels: first, they involve relevant real-world engineering challenges; second, they also involve competition against students from across the World. These kinds of educational activities appeal to the intrinsic interest of their students. That is, the project is of natural interest to the students so that they are motivated learn beyond the classroom.

The author has been involved with these activities for many years because of the value of these activities, to the students, to the university, to the profession, and to society. The results of the SAE alumni survey provide considerable support to that belief.

The alumni that participated in SAE activities believe that their education was enhanced by their participation. Further, these students gained valuable exposure to relevant professional and societal problems all while competing against other students from Universities from all over the World. This also expanded students' cultural horizons, introducing them to their peers from many other countries. Finally, the alumni responses also indicate that industry employers are benefiting because they are able to hire more experienced students.

Faculty, too, benefit from this collaboration. They can devote time to projects that enhance both undergraduate educational opportunities and their own research interests. This research not only leads to additional opportunities to publish and present, but also for additional research funding.

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Artistic Robot – An EPS@ISEP 2016 Project

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Abstract. This paper reports the design and development process of an artistic robot by a team of five engineering and design students from Belgian, Finland, Poland, Romania and Scotland. To contribute to this goal, the team designed and assembled GraphBot, a voice commanded drawing robot prototype, following the EPS@ISEP process. In addition, the team specified their target as young children and, in particular girls, and stated that their motivation was to introduce young generations to the world of science, technology, engineering and mathematics (STEM). In terms of outcomes, this project is expected to go beyond the boundaries of the traditional development of scientific and technical competences, by providing the students with a holistic learning experience, fostering also the development of personal and inter-personal skills within a multidisciplinary and multicultural teamwork set-up.

Keywords: Engineering education · Collaborative learning · European project semester · Robotic art

1 Introduction

This project was intended to develop technical, scientific and complementary skills in future engineering professionals within the European Project Semester (EPS) framework, which is a programme that brings together students from all over Europe [1]. It adopts a project-based learning approach, provides students with a multidisciplinary and multicultural teamwork set-up and challenges teams to design, develop and build together a solution for a real problem. In the case of this paper, the team embraced the challenge of creating an artistic robot while adopting marketing, sustainability and ethical practices.

The team decided to build a colour drawing robot for children, commanded by voice, named Graphic Robot (GraphBot). The robot should be able to draw in a different colour and to go forward, backward and change the direction. The area of

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drawing is defined by the paper size. The robot is intended to introduce children, in particular girls, to technology from an early age. The idea is to attract young girls to technology and, later, to study and embrace a career in a STEM-field. According to the United States (US) National Science Foundation, the number of females earning a bachelor's degree in electrical, mechanical, chemical and civil engineering in 2007 was 8368 compared with the 43 489 males [2]. The problem lies in the fact that traditionally girls are, from a young age, directed towards other fields than STEM and, therefore, few tend to choose an engineering related field for further education [3]. In this particular project, the team goal was to change this perception and introduce more girls to technology and engineering at an early age. According to the team's view, the robot should support creativeness – girls and boys should be able to play with the GraphBot, including those who are handicapped, and create art – and be versatile – should allow the reconfiguration and upload of altered or new code to the GraphBot.

The development of this robot is an opportunity to learn more about robotics and programming. The team had some limited experience with Arduino, but had never embraced a project of this size. As future engineers, this project is very interesting because it builds upon the multidisciplinary skills pre-acquired by the team members and develops new skills in robotics, which are in high market demand. The development of a drawing robot, taking into account project management, marketing sustainability and ethics, while working in a team composed of people with different cultural and study backgrounds was a challenge and an advantage. The team had the chance to learn from each other and, by sharing knowledge, achieve a common goal: bringing this project to a good end.

This project is an EPS@ISEP 2016 project, the European Project Semester offered by the School of Engineering of the Polytechnic of Porto – Instituto Superior de Engenharia do Porto (ISEP). This capstone programme was designed for engineering, design and business students. The students are divided in small groups from 3 to 6 students, preferably from different countries and study fields. Every group is given a different project to work on during one semester and there are modules that support the project development. In the case of EPS@ISEP, these project supportive modules include marketing, sustainability, ethics, project management, communication and an Arduino crash course. The students are supported by the EPS team, which consists of teachers from various study fields.

The specified robot requirements are the following: (*i*) move on a plane; (*ii*) work with different colours; (*iii*) be aesthetically pleasing; (*iv*) allow changing the drawing paper; (*v*) maximum dimensions of 1.0 m × 1.0 m × 0.8 m; (*vi*) reuse provided materials; (*vii*) use low cost hardware solutions and open source software; (*viii*) comply with the applicable EU Directives; and (ix) a maximum budget of 150 €.

2 State of the Art

The team researched similar products available on the market to identify pros and cons and to find inspiration to design an innovative drawing robot using a pen or marker to create art. The robot should be able to hold a pen and move it over a surface and may draw freely or follow instructions previously stored or provided in real time by a person.

2.1 Related Products

When researching existing types of drawing robots, the team discovered different types of devices, which are used by artists, companies and the public.

The robotic arm is one of the most commonly used products both in manufacturing processes and artistic projects, *e.g.*, mScara [4]. The robotic arm can draw smoothly and precisely. Although it is simple to build and aesthetically pleasing, the materials can be expensive. The arm can only cover a limited area.

The wheeled robot has typically two driving wheels, a caster wheel and a pen attached so that the device is stable and can draw over the paper surface, *e.g.*, mCar [5]. Although it lacks drawing precision and colour changing could prove to be difficult, it can operate over a large plane surface and is not expensive to build in terms of the parts.

The vibrating robot [6] adopts an erratic drawing method. These gadgets are used, but not particularly by artists, as they have virtually no control over what is being drawn. They are relatively cheap and easy to make.

The printer robot acts in the same way as a computer printer and allows the user to print on any type of surface [7].

One of the less well known methods of robotic art is the Eggbot [8]. Although this product is not used for writing on paper on a flat surface, it allows the user to draw on objects which are almost impossible to accurately draw upon. This method allows the user to print on difficult surfaces. The device allows painting of Easter eggs. This type of drawing machine can only draw on a limited number of objects.

The spider robot holds a single pen or marker through strings connected to the top corners of the vertical work surface, *e.g.*, mSpider [9]. In principle, when used with long strings, it can cover a large drawing area.

2.2 Comparison and Choices

After this related product review, the team compared the advantages, disadvantages, the parts required for the construction and their cost in order to decide the type of structure and input to be used with the GraphBot.

In terms of the robot structure, the team decided to adopt a wheeled robot approach. This solution allows the device to move and draw over a large surface. The structure of the robot is easy to build and the components relatively cheap. The programming of the robot is accessible and the cost of the building materials is within the pre-defined budget.

In terms of inputs, the team decided to command the robot in real time using sound. This option is natural to humans, can be used by people of all ages and can be fun. Whether it refers to words, tones or decibel levels, sound communication is easy for humans and supported by robots. Moreover, if the user is allowed to define his own robot commands, then he feels more connected and involved with the product.

3 Proposed Solution

The team, in order to find a solution to the development of the drawing robot, addressed the project management, marketing, sustainability and the ethics involved within the corresponding EPS@ISEP supporting modules.

3.1 Project Management

Project Management is one of the main aspects needed to realize a project. It is an important tool, which enables the team members or the project manager to: (*i*) measure the risks of the project; (*ii*) analyse the responsibilities of the people involved; (*iii*) monitor the cost and the budget; (*iv*) define the product requirements; and (*v*) manage the duration and deadlines of the individual tasks.

Most importantly, project management allows team members to follow the daily schedule and monitor the deadlines. Thanks to the use of tools such as “Microsoft Project 2016” and Gantt charts, the team was able to assign the tasks to team members, set proper deadlines, define the expected duration for each task and deliverable, and monitor the project progress. In addition, communication turned out to be an important role in the project development. In the very beginning, the team decided to arrange all meetings through social media or mobile contact. Thereby, whenever a team member faced a problem, he or she could immediately obtain the appropriate help and feedback from others. Project management allowed the team to allocate, monitor keep up to date with all the tasks.

3.2 Marketing

After conducting a marketing study on drawing robots, the team chose to target children between the ages of 5 and 12 and, in particular, girls. The idea behind this decision is to attract and interest girls in STEM. This would allow GraphBot to contribute to balance genders in typically male dominant fields and promote the understanding of technology at an early age. The team believes that, by having fun and being creative with the GraphBot, children will develop new skills and gain an edge. The GraphBot, while an educational toy that can draw through voice command recognition, is an innovative product, filling a gap in the market.

3.3 Sustainability

Sustainability is a concept involving environmental, economic and social perspectives regarding the production process and the product life cycle. The environmental aspect is important for the eco-efficiency of the process and product. The economical aspect includes using resources and money in an efficient manner [10]. The social aspect takes in consideration the customer needs as well as the goals of the project, i.e., build a fully functional product. To cover all issues of sustainability, the team implemented a life cycle analysis [11] regarding the whole product development, *i.e.*, from design until recycling. The life cycle analysis is divided into: (*i*) design process; (*ii*) manufacturing and assembly; (*iii*) packaging; (*iv*) use of the product; and (*v*) end of life.

The implementation of sustainability measures gave the team a greater understanding of the impact of the activities involved in the creation of a prototype. The team implemented a life cycle analysis to make the product as sustainable as possible, *i.e.*, by selecting low cost materials, components based on their energy consumption and recyclable materials like glass, rubber, plastic or wood for the structure. Furthermore, the customers' opinions were considered during the design and development of the prototype because their feedback helped the team to refine the product.

3.4 Ethics and Deontology

The main areas that the team considered throughout the process in terms of ethical and deontological concerns are: (*i*) engineering ethics; (*ii*) sales and marketing ethics; (*iii*) academic ethics; (*iv*) environmental ethics; and (*v*) liability.

Engineering ethics is arguably the most related to the project as it deals with the health and safety aspect in relation to the members of the team, others involved in the project and the general public [12]. It also takes into consideration that people working on the project must carry out tasks to the best of their ability in the fields in which they are qualified. Sales and marketing ethics includes the research of products which are already on the market and the research of potential customers in an ethical manner. Pricing and the relations between the competitor products is also important to help ensure that the team created a trustworthy and attractive product for customers. The promotion of the product was also contemplated in an honest manner, *i.e.*, without misleading statements. During the process, the utmost care was taken when selecting products and materials to ensure that they were sustainable, *i.e.*, without hazardous substances. Liability takes into account the various applicable directives to help create a product which is legal to place on the market and safe to use.

3.5 GraphBot

Based on the performed marketing, sustainability and ethical analyses and multiple discussions, the team specified that, in addition to the initial requirements, the GraphBot should: (*i*) recognize simple voice commands and respond accordingly in a timely manner; (*ii*) be user-friendly, easy to use and robust; (*iii*) detect the drawing area automatically; (*iv*) change the drawing colour easily; and (*v*) provide access to the micro-controller interface, allowing the refinement of the code for more advanced use. With this set of requirements clearly defined, the team decided to adopt a wheeled robot design and focussed on addressing the following open issues: how to change the drawing colour?, which components to choose?, how to assemble the electronic and structural components? and how to control the system?

First, the team tackled the design of the GraphBot, creating the structure, casing and including a four pen rotating holder for colour changing. The casing houses and protects the control system. Figure 1 presents the preliminary sketch of the GraphBot, a

Fig. 1. Preliminary sketch of the "GraphBot" prototype (3D model)

two-wheeled robot equipped with four different colour pens. It accepts voice commands and draws on a horizontal paper.

Then, the team addressed the question of choosing the materials to build the structure and the electronic control system. Table 1 displays the list of the selected electronic components.

Table 1. List of electronic components

Component	Qty.
Arduino Uno R3 micro-controller	1
EasyVR shield for voice recognition	1
Stepper motor for changing the colour pen	1
Direct current (DC) motors for the robot driving wheels	2
L293D motor driver	1
Lithium polymer battery	1
Infrared (IR) sensor to detect the drawing area	1
Microphone	1
Speaker	1
On/off switch	1
Protoboard	1

The team chose to build the casing in recyclable plastic using a 3D printer. The placement of the electronic components inside the robot was also contemplated.

Figure 2 displays the main control functional blocks – micro-controller, voice interface, motion control and drawing control – as well as the implemented functionalities. When, for example, the voice interface receives a FORWARD voice command, it informs the micro-controller, which, in turn, actuates the motion and drawing control blocks.

Figure 3 shows the placement of the components inside the GraphBot.

The microphone, speaker and complementary components are assembled on a dedicated printed circuit board (PCB) attached to the upper part of the casing. The microphone is used to receive the user inputs and the speaker provides feedback, *i.e.*, informs whether the voice command was recognized. The microphone and the speaker are connected to the EasyVR shield.

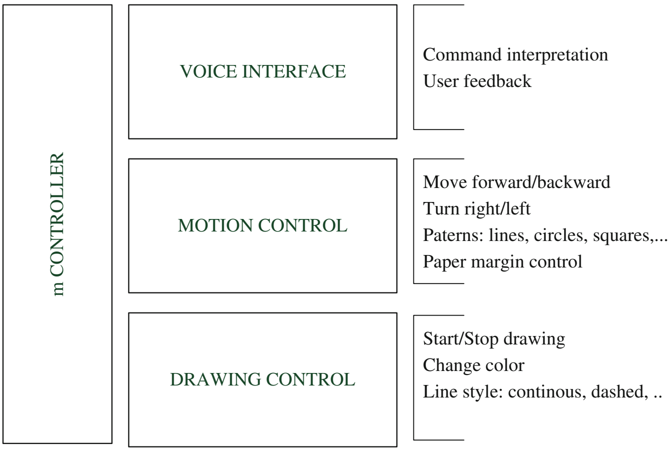

Fig. 2. Block diagram

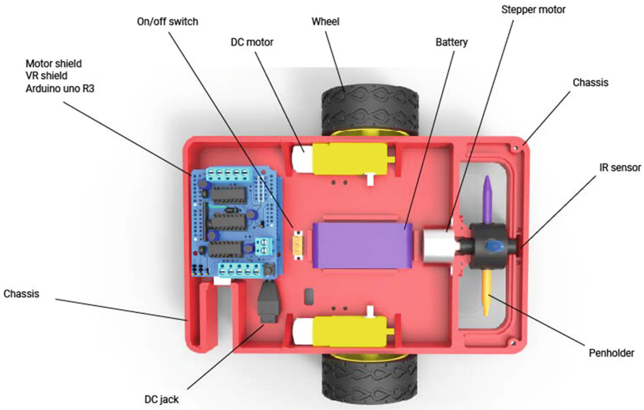

Fig. 3. Placement of the components inside the GraphBot (3D model)

The stepper motor, which is used to control the colour pen change, rotates the penholder. The two direct current (DC) motors implement a differential motion system on the wheels. All motors are connected to the micro-controller through the L293D motor driver. The caster wheel is placed underneath the rear of the robot for extra support. The GraphBot detects the edge of the paper using an IR sensor placed on the bottom front.

A 7.2 V lithium polymer ion battery powers all electronic components. The battery is placed in the centre of the robot and is accessible for charging through the bottom. The DC jack is used to connect the Arduino to the battery.

To ensure the right amount of pressure while drawing, each pen casing has a spring to push the pen against the paper. The penholder is connected to the stepper motor using a flattened shaft fitted into the wheel, as shown in Fig. 4.

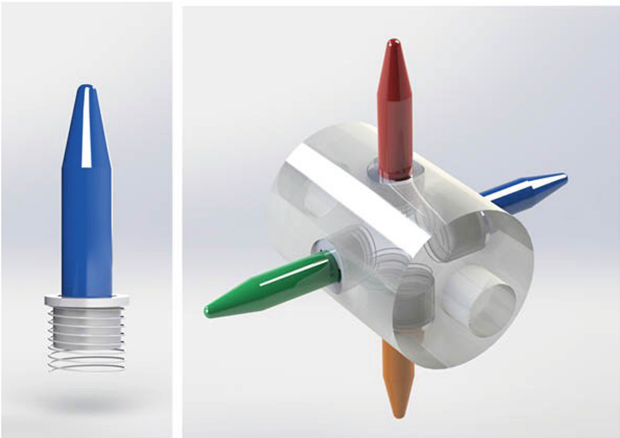

Fig. 4. Pen changing mechanism design (3D model)

To hold the pens there is a turning mechanism in the penholder, as shown in Fig. 5.

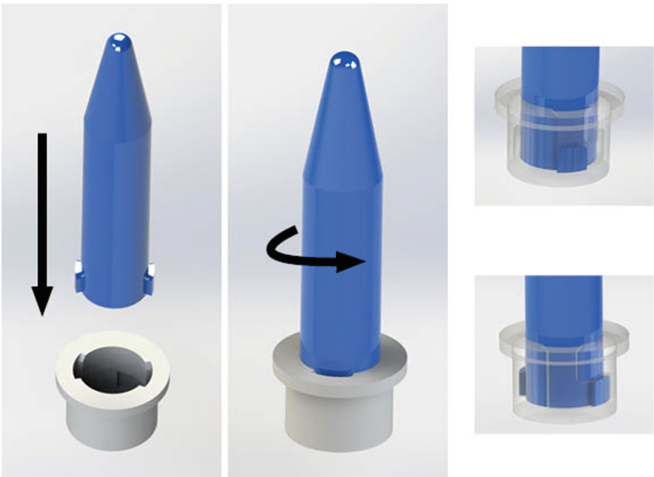

Fig. 5. Single pen design (3D model)

4 Discussion

The EPS is a one-semester capstone project/internship programme offered to engineering, product design and business undergraduates [13] by 18 European engineering schools. EPS aims to prepare future engineers to think and act globally, by adopting project-based learning and teamwork methodologies, fostering the development of complementary skills and addressing sustainability and multiculturalism.

The EPS@ISEP is a 30 European Credit Transfer System Units (ECTU) programme with six modules: Project (20 ECTU), Project Management and Team Work (2 ECTU), Marketing and Communication (2 ECTU), Foreign Language (2 ECTU), Energy and Sustainable Development (2 ECTU) and Ethics and Deontology (2 ECTU). These 2 ECTU modules are project supportive seminars oriented towards the specificities of each team project [14].

According to the 10 Golden Rules of EPS [14], the EPS teams should be multidisciplinary and multicultural to develop cross-cultural communication and collaborative learning skills among team members. Therefore, in every edition, the EPS@ISEP programme offers a set of multidisciplinary projects, so that each team member can contribute with his/her expertise and background experience. One of the project proposals offered in the spring of 2016 was the development of an artistic robot.

The objective of this project was, not only, to have the students implement a final prototype, but also to make them contribute with their distinct visions of the problem to a common solution. This project development process is demanding for students, since at this educational level, they are not used to collaborate with individuals from different nationalities (implying distinct cultural backgrounds) and specialization fields (engineering, business and product design), nor to be autonomous and responsible, *i.e.*, they have to make decisions and reach consensus. This approach develops communication, negotiation and collaboration skills, which are usually lacking in students following traditional learning approaches.

The students enrolled in this project started by performing a state of the art analysis regarding the existing solutions and addressing the marketing, sustainability and ethical perspectives of the process and product. After several brainstorming sessions, they agreed on the prototype design – a wheeled robot with a rotational head to accommodate four colour pens – as well as on the type of user input – voice commands. The final product is expected to be used by young girls, in particular, and children, in general, while a motivational fun toy, to foster the interest for STEM fields at a young age. The team anticipated alternative application areas, *e.g.*, the use GraphBot in paediatric wards, services and clinics.

In terms of dissemination and communication materials, the team maintained a project wiki (http://www.eps2016-wiki1.dee.isep.ipp.pt/) and produced multiple deliverables, including a report, a paper (the base of this document), a video, a leaflet (see Fig. 6), a user manual and two presentations.

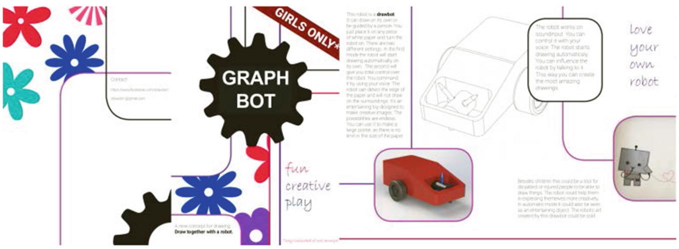

Fig. 6. GraphBot leaflet

During the execution of the project, the team was faced with different challenges. The main difficulties were task planning, in particular the estimation of the duration of the planned activities and cost estimation. According to the team, this problem resulted from the lack of experience in managing and developing projects in general. However, the ability to overcome together the difficulties provided learning opportunities, encouragement and satisfaction. When they realized that were learning from their mistakes, they got motivated and confident in their ability to develop the GraphBot. This way, the team elements gained confidence in undertaking projects involving multidisciplinary and multinational teams, which contributes to their future employability.

In terms of the personal and learning outcomes of this process, the students have gained autonomy, self-confidence and have developed technical, scientific and complementary skills with this multidisciplinary, multicultural teamwork experience – the design and development of a prototype. Table 2 provides the opinions of the five team members regarding this experience.

Table 2. Student testimonials

"The European Project Semester at ISEP was a great life experience. I very much enjoyed working on and developing the GraphBot with my teammates from all over Europe. As we are a multidisciplinary team, I could learn from other members when working on some parts of the project in which I was less experienced."
"The European Project Semester has been very good practice on engineering and project work in general. Working as a group on a problem for a full semester is a good way to learn important skills that are needed in the future. I have done a lot of different group work before, but never anything like what the EPS has to offer. Working on a practical project in a multinational group is a great experience for anyone."
"For me, participating in the EPS and in an Erasmus exchange was one of the greatest experiences in my life. The most important thing is that I learned how to live on my own, how to communicate and live with different people, going beyond the language and culture boundaries. Participating in an EPS is really great preparation to start your own company and shock the world with a breath-taking innovative solution. Being a team made of people with different skills and coming from all over the world together, we were able to make our dreams come true and assemble a working prototype. We learned the importance of cooperation, *i.e.*, that acting alone does not achieve the same success as a team! Trusting a team member does not only allow you to work properly, but creates friendships, which may even last after EPS is ended. Facing problems and difficulties during project development was an opportunity to learn to invent solutions for unexpected situations. Being an engineer is being able to design a solution for a problem, and this is exactly what EPS teaches you."
"EPS is a very good way to learn how to work independently as a team. The experience teaches that people have very different views on how to work as a team. It is not easy to cooperate smoothly. There are always struggles in a team. I believe there are even more struggles in an EPS-team. It is a challenge to overcome all these extra differences. There is support from the teachers, but problems have to be sorted out by the team alone. It is hard to anticipate the knowledge and capabilities of the other team members, which often leads to misunderstandings. The EPS programme has thought me a lot about teamwork and has given me an insight regarding different cultures and study fields."
"The EPS Program has been a good experience. I never did anything like it before. To work with different people from different countries and cultures is wonderful since I met eager students who enjoyed this project with me. I am glad I am a part of the best team I have ever worked with. Together we have made some good memories. I visited beautiful places in Portugal with wonderful views and I recommend everyone to come here and join this programme. I learned how cooperation is essential and how important it is to work as a team. Five people from different countries in one team can realize extraordinary things. I learned that it is important to find a good solution as soon as possible to overcome any issues. In conclusion, with EPS@ISEP and Erasmus you do not have anything to lose."

5 Tests and Results

Regarding the main functions of the robot, the team adopted an incremental testing approach, *i.e.*, they tested each module separately, and, finally, integrated and tested all components.

Regarding the main functions of the robot, the most important is the Voice Recognition. First, the team connected and tested the speaker to make sure that it worked properly. Next, they tested the recognition of the voice command with the pre-programmed command "ROBOT". Once this was achieved, the team programmed the EasyVR to recognize five commands: "FORWARD", "DOWN", "LEFT", "RIGHT", "CHANGE" and "STOP". This test was successfully performed with one team member issuing the voice commands and the speaker giving positive feedback. The next stage was the test of the motors, involving the control of the two wheels, using the Motor Shield and two DC motors, and of the stepper motor. The two motion wheels, which are attached to the DC motors, were able to move and the stepper motor, which is connected to the penholder, was able to rotate the specified angle. The following step was to integrate the voice recognition with the control of the motors (see Fig. 7). At this point, the team discovered that the current from the USB interface was insufficient to drive the GraphBot and solved this problem with the use of an external power supply. To verify if the GraphBot correctly identifies the boundaries of the drawing area, the team first tested the IR sensor and it was able to distinguish between the white sheet of paper (a reading of approximately 40) and the table surface (a reading of approximately 1000). Figure 8 displays the prototype at this point of assembly.

The test of the Motion Control module involved testing the Motor Shield and IR sensor. The operation of the DC motors together with the detection of the drawing area was successful.

The testing of the Drawing Control module, regarding the rotation of the penholder both for drawing and colour changing, was successfully performed with the help of the

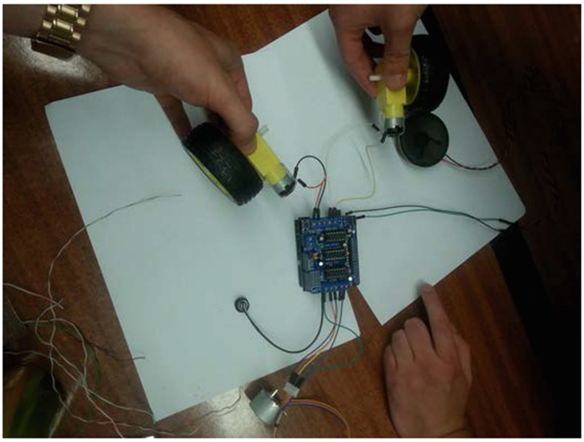

Fig. 7. Initial tests set-up

Fig. 8. GraphBot prototype

stepper motor, *i.e.*, the penholder rotated according to the angles specified in the code. The next step was the placement of the ON – OFF switch between the battery and the Arduino in order to be able to turn the device on and off. After assembling all parts and updating the code, the GraphBot was ready for the final tests (Fig. 9).

Fig. 9. GraphBot prototype with button

The GraphBot, once switched on, runs the initialization and, then, makes a “beep”, indicating that is ready, *i.e.*, is waiting for a voice command. The time frame for the recognition of a voice command is 5 s, after which it makes a new “beep”. Simultaneously, the IR sensor reads the value of the reflected light from the surface. If this value exceeds the pre-defined threshold (900), it means that the robot is out of the drawing area and the DC motors stop. When it receives a new command, *e.g.*, a “FORWARD” command, it checks the IR value and only moves forward if the reading is below the threshold. When the robot turns right, the left and right wheels move simultaneously forward and backward for 0.3 s, respectively. This approach allows the Robot to rotate approximately 90º. The same applies when it turns right, reversing the motion direction of the wheels. When the user gives a change colour command, the stepper motor rotates 90º from its current position by making 500 micro steps forward. This operation is performed in background, while waiting for voice commands. The "STOP" command immediately disables both DC motors.

The final tests identified some problems: (*i*) the wheels touched the chassis, requiring a higher torque and drawing imperfect straight lines; (*ii*) the microphone of the EasyVR proved to have low sensitivity, ignoring the voice commands at times; (*iii*) the markers occasionally got stuck or did not touch the paper; and (*iii*) the robot failed to detect the end of the drawing area when moving backwards. The team solved the first issue by rearranging the positioning of the wheels in relation with the chassis. Regarding the second issue, the team believes it can be solved with the selection of a more expensive microphone, and, regarding the last issue, the team believes it can be addressed by positioning a second IR sensor at the back.

In terms of design, the initial prototype suffered from the fact that the user had to detach the top to press the reset button of the motor shield since the EasyVR shield requires a reset at start up. The team chose functionality above aesthetics and added a button on top of the GraphBot. As a result, to interact with the GraphBot, the user first switches on the button in the bottom and then presses the button in the top. Figure 9 shows the button on the top of the prototype.

6 Conclusion

This paper reports the EPS@ISEP design and development process of the GraphBot, a voice commanded drawing robot, by a team of five engineering and design students from Belgian, Finland, Poland, Romania and Scotland.

This one semester process, which started with the initial proposal requirements, involved multiple team brainstorms and studies, including the state of the art review as well as marketing, sustainability and ethical and deontological analyses, in order to define, implement and test a solution.

The team achieved the main goals of the project. The user can, through voice commands, direct the GraphBot to the left, right, backwards and forward, change the drawing colour and stop drawing. The robot stops automatically when it detects the end of the drawing paper. After the final tests, three problems remain unsolved regarding the: (*i*) the voice recognition – sometimes the user needs to repeat the command or the command is wrongly interpreted; and (*ii*) the penholder mechanism – the markers occasionally get stuck or do not touch the paper; and (*iii*) the detection of the drawing area when moving backwards. However, given the timespan of the project (4 months) and the budget spent (120 €), such problems are likely to occur.

Taking into consideration the current development state of the prototype, there are opportunities for further improvements, *e.g.*, the adoption of a solar power source, gesture control or innovative drawing techniques as well as the possibility to upload drawings. Last but not least, the GraphBot could evolve to support reconfiguration and customisation, allowing children to change the code and define customised commands.

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Didactic Robotic Fish – An EPS@ISEP 2016 Project

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Abstract. This paper presents the development of Bubbles, a didactic robotic fish created within the scope of the European Project Semester offered by the School of Engineering of the Polytechnic of Porto. The robotic toy is intended to provide children with an appropriate set up to learn programming and become acquainted with technology. Consequently, Bubbles needs to appeal to young children and successfully blend fun with learning. The developer team, composed of five engineering students from different fields and nationalities, conducted multiple research and discussions to design Bubbles, while keeping the fish movements and programming simple. The fish body was created with a colourful appearance, ensuring floatability, waterproofness and including a tail, inspired on real life fish, for locomotion and to retain a fish-like appearance. Finally, the team designed a website where they share, in different languages, the blue-prints of the structure, the schematics of the control system, the list of material, including electronic components, the user assembly and operation manual as well as propose exploring activities.

Keywords: Engineering education · Collaborative learning · European project semester · Robotics · Biological inspiration · Programming

1 Introduction

The European Project Semester (EPS) is a one-semester capstone project/internship programme offered to engineering, product design and business undergraduates [1] by 18 European engineering schools. EPS aims to prepare future engineers to think and act globally, by adopting project-based learning and teamwork methodologies, fostering the development of complementary skills and addressing sustainability and multiculturalism. In particular, multidisciplinary and collaborative learning are pervasive concerns within EPS projects.

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The EPS@ISEP programme – the EPS programme provided by the School of Engineering – Instituto Superior the Engenharia do Porto (ISEP) – of the Porto Polytechnic – welcomes engineering, business and product design students. The EPS programme is a 30 European Credit Transfer Units (ECTU) package structured as follows: 20 ECTU assigned for the project module and 10 ECTU for complementary modules. These are focussed on the development of soft skills considered essential for 21st Century Engineers, such as communication or teambuilding, project-related activities such as project management and transversal topics such as sustainability and ethics and deontology. By default, EPS, as an engineering capstone programme framework, is intended for the final year of the engineering programme. The EPS providers have discussed, agreed upon and posted on the EPS Providers site the European Project Semester framework. These are the so-called "10 Golden Rules of EPS" that an EPS provider must comply with: (*i*) English is the working language of EPS; (*ii*) EPS is multinational with a group size of minimum three and maximum six students, being four or five the ideal number; a minimum of three nationalities must be represented in each EPS group; (*iii*) ideally, but not necessarily, an EPS project is multidisciplinary; (*iv*) an EPS semester is a 30 ECTU package, the duration of which is not less than 15 weeks; (*v*) an EPS project has a minimum of 20 ECTU and the complementary subjects account for a minimum of 5 ECTU and a maximum of 10 ECTU; (*vi*) the main focus on EPS is on teamwork; (*vii*) the subjects included in the EPS must be project supportive; English and a basic crash course in the local language must be offered; (*viii*) the subjects must include Teambuilding in the very beginning and Project Management in the beginning of an EPS semester; (*ix*) project supervision/coaching must focus on the process as well as the product; and (*x*) EPS must have continuous assessment including an Interim Report and a Final Report [2].

Upon arriving in the city of Porto and to begin the European Project Semester programme each individual student was provided with a Belbin test in order to separate the students into teams from all different backgrounds, fields of study and personalities. Once this has been decided by the programme leaders, a list of different projects was given to each team to select its preferred project. Team three was allocated their first choice, a didactic robotic fish. This project is now being undertaken by a multinational team of students from several different countries and educational backgrounds dedicated to building a successful design. The team was provided with a budget of 50 €, making it is vital that reusable items were used and low cost solutions examined.

The 21st century is a digital world. In this world, the technologically literate flourish, while those stuck in the ways of the past may be left there. If technological education is left solely to a wildly varying set of international education standards, many children will miss out on the exposure to programming and electronics during their formative years. The team researched and discussed numerous ideas and came to the conclusion that the fish would be an educational learning programming in electronics targeting young children between the ages of five and ten years old. The option for a fish like robot is based on the notion that kids love to play in the water and this will allow them to learn robotics and programming in an enjoyable environment. The creation of this robot will enable young children to gain an excellent introduction into the world of electronics and programming.

The didactic robotic fish was selected by team three that consisted of five students: Achim Reinhardt a media and technology student from Germany, Alvaro Chousa Esteban an Engineering and Architecture student from Spain, Justyna Urbanska a Logistics Management student from Poland, Martin McPhee an Electrical Engineering student from Scotland and, finally, Terry Greene a Mechanical Engineering student from the U.S.A. The EPS programme creates a diverse background within each team, and each member comes with their own specific set of skills and knowledge.

The main objective for this team was to construct a unique, fun and educational product that has the ability to teach young children about the basics of programming. It is essential that the completed model is appealing to the target market and must be simple enough for people with limited knowledge of programming to work with. Although this product is aimed at creating a deeper insight into the world of programming it is still none the less a child's toy and must be robust enough to withstand minor abuse that has the potential to occur. This early introduction into programming could lead to these children in the future becoming motivated to pursue a career in engineering or similar fields whilst gaining a deeper understanding into the programming environment. It is important that the robotic fish will be at a reasonable price allowing all children of many different backgrounds the opportunity to use this educational toy. This marketing idea was identified due to research of similar products that are available on the current market. However, a considerable number of these products are out of the price range for some families who are on a lower income. The purchasing of Bubbles will also provide the owner with a digital user manual to assist in the process of setting up the toy for use in an aquatic environment. A substantial website has been created with reference to Bubbles and will contain fun activities and effectively be able to answer any queries or questions people that might concern them.

The purpose of this paper is to highlight the EPS experience and, although design, implementation and the more technical stages of the creation of a didactic robotic fish are focused, during the course of the EPS programme students took part in several different classes namely, Ethical and deontological concerns, Marketing, Eco-efficiency measures for sustainability, Communications and finally Project Management. These classes were part of the programme to enable the students to successfully complete the project whilst gaining an understanding on a wider range of subjects that were vital to the creation of the didactic robotic fish Bubbles.

Given this brief introduction, Sect. 2 presents a brief review of the state of the art, introducing some systems that were analysed by the student's team before starting the development of Bubbles and Sect. 3 is devoted to the description of the work developed by the students in the EPS project supportive modules. In the sequel, Sect. 4 presents the design architecture of the prototype, Sect. 5 the programming language adopted for the development and Sect. 6 the tests performed on the final prototype. Finally, Sect. 7 presents a discussion of the EPS work and Sect. 8 concludes the paper with the presentation of the main conclusions.

2 State of the Art

Programming is apparent in everyday life and it is vital to understand the process. To enable sufficient understanding of process, coherent educational programming languages were developed and designed for children and beginners that are enthusiastic about the opportunity to learn about programming. Investigation took place on the current robotics market to examine existing products, bringing them together for comparison to ultimately create the unique design. The didactic robot fish is essentially a toy that has the ability to float on water and move to either the left or to the right. As we move further into this paper, in depth analysis will be completed to show the path that lead the team to the final model and to focus on the languages, where simplification of the programming process occurred to help new programmers become familiar with the main functions and principles.

2.1 Existing Products

There is currently on the market a great selection for robotic toys, however not every robot meets everyone's demands. It concerns the destiny of a robot and its technological advancement. Bubbles is an educational toy for teaching young children the basics of programming through play. Therefore, it is important to check the robots that have been developed for a similar purpose, namely to the child's education. In addition, it is important to focus on high-technology works.

Undeniably, the market leading the way in educational learning is Sphero 2.0 [3]. For many years it has maintained its leading position. It is a ping-pong ball, which pairs with iOS and Android devices via Bluetooth. This allows children to control and programme ball and is fairly simple to use. Sphero is powered by induction charging and has the ability to alter its colour.

Another robot is Ozobot [4]. Its task is to teach children about coding and to allow them to use logical thinking whilst also having fun. By drawing coloured lines in the red, green, blue and black colours, children can control and influence the behaviour of the robot. Ozobot is programmed to memorise and repeat 500 different moves to create unique dance routines that are set to your child's favourite songs.

Dash & Dot are specific types of robots that can hear sounds, detect objects, and also detect movement [5]. They can be programmed using visual programming editors called Blockly. It comes with the pair, dry as a xylophone, mallet, smartphone mount, tow hook, bunny ears, tail and more.

It is difficult to find aquatic robots for children's education and this paved way for an opportunity for the team to create one of a kind. We can distinguish robots like Robofish [6], Soft Robotic Fish [7], Tamiya Mechanical Blowfish [8] as these were constructed in a similar way as Bubbles. A crucial feature of the robofish is that it has the ability to successfully float and change direction, to the right and to the left. With regards to the soft robotic fish, it is an autonomous soft-bodied robot that is both self-contained and capable of rapid, continuum-body motion. The Tamiya Mechanical Blowfish is a device used to teach physics and mechanics.

3 Project Supportive Modules

3.1 Project Management

In order to create a successful project, it is essential that a project management plan takes place to ensure all of the appropriate methods, skills and knowledge are used. Implementing project management is most likely the most important aspect of a project allowing the team to regularly check the cost and monitor the budget as it is restricted to 50 € and must not be exceeded. It will also identify any potential risks and how to overcome then appropriately. Project management allows the team to manage the work load that is presented to them as each week throughout the semester there were targets and deadlines to meet. It was appropriate to identify the targets that the team identified and the scope of activities:

- To create user-controlled robotic fish suitable for children in age 5–10;
- To use waterproofing materials which is safe for users;
- Select or create a programming language that is simple for children to use at the appropriate age range;
- To create the fish as inexpensive as possible to remain within the limits of the budget provided.

There were several tools used to ensure that targets were met each week as a team and for the individually selected task and this was achieved with the use of a Gantt chart. The Gantt chart has shown to be a very useful tool in the planning of the project and using successful time management. It aided in the process of planning each task for each week and identifying individual tasks set for team members. Finally, communication played a vital role in the completion of the project and maintaining a constant work as there had to be communication to allow each member of the team to know exactly what their task would be for that particular week. To achieve this, the team would regularly communicate with one another through Facebook, WhatsApp and by text, enabling the team to regularly keep in contact and ensure no one was left unsure of their job. If any problems did arise it was simple enough for other members to speak to them and work together to solve the issue.

3.2 Marketing

The market that was identified to specifically target was young children. The aim was to be appealing to children between the ages of 5 and 10 years old. Bubbles, the robotic fish, is essentially a children toy, however it is also going to be used as an educational learning programme to provide these young people with an insight into the world of engineering and robotics. This can only be beneficial to the children as if introduced early enough they could develop an interest in engineering and aspire to learn more with the possibility of a future career in the industry. Bubbles once placed into water, operates by a programme that is controlled by the user and has been made quite simple as to not confuse the young people that will be using the device. The movements of Bubbles are limited to simply, left and right and will also importantly be able to float.

3.3 Eco-Efficiency and Sustainability

The main purpose of sustainable development is to provide solutions for the preservation of natural resources. Its target is to spare water and to reduce humans' negative impact on the environment and human health. In general, there are three different subsections of Sustainability:

- Economic sustainability is concerned with creating a healthy and stable business.
- Social sustainability is concerned with creating a fair and decent work environment.
- Environmental sustainability is concerned with using energy and resources efficiently and sustainably, without producing trash.

For the creation of Bubbles, sustainability is a very important part of the project regarding as it is essential nowadays to be environmentally friendly. This is achieved by identifying and using environmentally friendly materials, reusable components and finally eco efficient transportation. Reusable components were not only pivotal to creating an environmentally friendly robotic but also to remain with the refines of the 50 € budget. The components of Bubble that can be easily recycled is the battery and polylactic acid body.

The purpose of economical sustainability is to provide strategies which optimise the use of existing resources. This is necessary to produce the product efficiently and profitably over a long period of time. An important aspect of an efficient economy is the contribution of the local economy. For this reason, this project will acquire all components from local providers in Portugal. Through this, the economy of the country is supported.

The purchase of the didactic robotic fish, allows children to take their first steps into a programming environment and potentially then onto a future career in the industry. It is economically vital to keep Bubbles price low as children disenfranchised by similar and more expensive products will be able to explore the world of programming for the first time. In today's world, where robotics is an important and ever expanding field, qualified programmers are pivotal to the growth of the economy.

The general definition of social sustainability is the ability of a social system, such as a country, to function at a defined level of social well-being indefinitely. Bubbles was developed to provide a toy that can be available and affordable to everyone, regardless of their background or social stance and can help to remove the gap between what is deemed as the rich and the poor. On a smaller scale this project can take small steps in trying to enable equality in society and defend human rights and for this to be successful Bubbles had to be created at a fair price that is affordable to engage children and adults alike into the electronic world. Currently on the market there are several similar products, however they are unfortunately out of the price range of some families. Bubbles, therefore, stands out as not only a toy but an educational tool for children of any background, it is a fun and simple way to create an attraction to programming and provide the opportunity of a better future.

3.4 Ethical and Deontological Concerns

Throughout the duration of this project there are five critical points that are in relation with both ethical and deontological concerns. These are as follows Engineering, Marketing, Academics, Environmental and finally liability ethics. It is pivotal for the construction of the project that each one of the topics mentioned are fully taken into consideration when making decisions.

Engineering ethics relate directly to safety, this is essential that each team member works appropriately and is in no danger of harm, it is also important that no one else around them is in danger. Ethics are critical in stressing as engineers, the health and safety regulations and responsibility to conduct them.

Sales and marketing ethics is essentially the relationship between the researcher and the client, the researcher and the marketing research history. It will provide details of existing products currently on the market, how to promote the product fairly and to conduct research on potential customers. Marketing is important to the creation of Bubbles as not only must it operate efficiently and correctly but it must be appealing to the target market therefore, appearance and promotion are key.

It is vital for the group to continue to follow the codes of environmental ethics and to perform this duty by carefully selecting the best available materials that are not a danger to the natural world. It can be as simple and ensuring that everything possible has been done to attempt to reuse materials, preventing the need for the creation of new components. The design of the robotic fish will be done so with regard to the environment are where possible a design will be created that can be environmentally friendly.

In order to complete the creation of the didactic robotic fish it is essential that we comply with the following EU directives to ensure that it is legal to place on the market and meets the safety regulations:

- Toy safety directive (2009/48/EC-2009-06-30)
- Waste electrical and electronic equipment directive (2012/19/EC-2012-07-04).

4 Design Architecture

The specified goal of the robotic fish is to create a robot able to swim in the water which has at least a single degree of freedom. In order to provide this movement, the design team looked to nature. Millions of year of evolution has filled the oceans with the perfect swimming machines: fish. 85% of fish utilize body and/or caudal (back) fin (BCF) locomotion as their main source of propulsion [9]. So this was the inspiration for the design. The following section focuses on that design architecture and the decision making process behind it.

4.1 Locomotion Mode

It was decided early on to mimic BCF propulsion in the robotic fish. However, this form of movement falls on a spectrum from undulatory to oscillatory. These classifications concern how the propulsion wave propagates from the tail through the body [10, 11]. With the imposed design restrictions of this project, Ostraciiform Locomotion made the most sense. In accordance with the project charter, the fish should be inexpensive, controlled by servo motor(s), and have a 3D printed body, and there is no simple way to create undulatory movement without sacrificing one or more of these tenets.

4.2 Body

The body shape is based on that of a typical wider body of ostraciiform fish, like the box fish and the puffer fish. It is approximately 150 mm long and with a compartmentalized interior, designed to house all of the fish's electronic components (Fig. 1). The design was created in Siemens NX™10. The main body consists of two pieces, a top and bottom. These are connected via bolts and separated by a waterproof gasket.

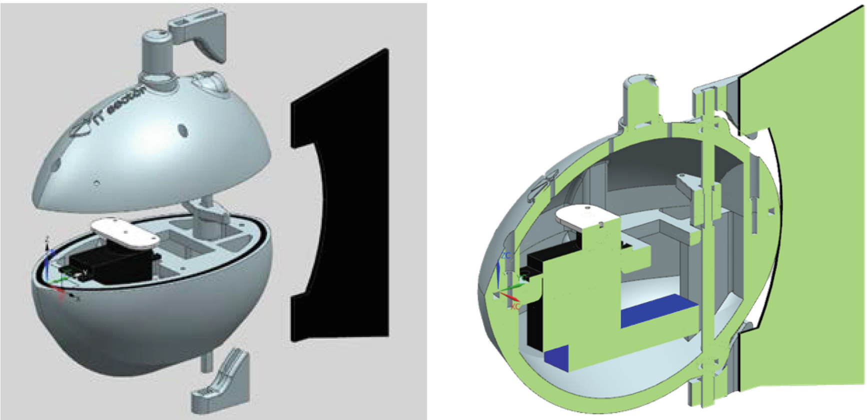


Fig. 1. Exploded (left) and cut of the fish body model (right)

As dictated by the project directives, the body is 3D printed. This print was completed using polylactic acid (PLA) due to its easy printability, nontoxicity, and biodegradability. With these factors in mind, PLA is the suggested material should the fish ever be reproduced. However, the body can be created using any 3D printable material.

4.3 Mechanics and Control

The motion of the fish is provided by a single servo motor connected to the rear fins drive axle via springs. The springs dampen the motion and help to prevent component damage from repetitive stress. The axle, which is split into two sections to allow for simple disassembly, leaves the interior of the fish through holes waterproofed with

O-rings (Fig. 2). The control of movement is dictated by an Arduino Nano which is custom programmed by the user. In order to start an input program, the user removes a magnet from the exterior surface of the fish. This magnet opens a reed switch, and the Arduino begins to run its code.

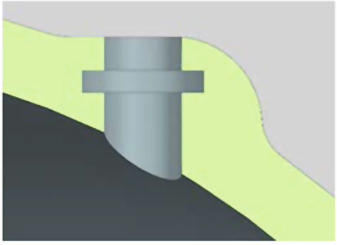


Fig. 2. Groove to allow for O-ring

4.4 Caudal Fin

The fish's tail is attached to its drive axle on either side of the body using small 3D printed components affixed to axle (Fig. 3). These attachment pieces will be slid over a flattened portion of the axle and secured via setscrews. The tail is to be made from a semi flexible rubber or plastic. By making the attachment module though, the design allows for the testing and use of a variety of tail material.

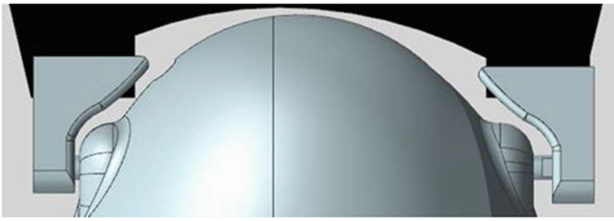


Fig. 3. Tail attachment points

5 Programming

In order to create a programming language which is suitable to the cognitive abilities of the target user, it was considered to use a block or text based development environment. Different from the text based programming concept, the block based concept relies on blocks which can be arranged by the user to create programming processes. The advantage of this workflow is that a correct syntax and terminology do not have significance because the user can only use pre-built elements. On the other side, block based programming cannot reach such a high level of complexity and functions as text based programming. Since a high level of complexity and enormous functionalities are not needful for the requirements of this project, the team decided to use the concept of block based programming.

5.1 Language

To realize the software the team decided to use the open source code of Ardublock as foundation. Ardublock is specially designed for the application in Arduino [12]. It is based on Openblock which is an extendable framework for block based programming environments developed by Ricarose Vallarta Roque at the Massachusetts Institute of Technology [13]. The reasons for choosing Ardublock are the open source accessibility and the direct implementation in Arduino. That means Ardublock can be directly accessed from Arduino interface. The different shapes and colours of blocks and connectors ensure the compatibility to each other. According to the arrangement of the blocks, Ardublock creates text code in the Arduino syntax. This automatic process avoids Arduino code syntax mistakes but logical mistakes can still happen.

It was necessary to change the source code of Ardublock for creating custom elements specially design for the capabilities of the fish robot, and all elements which were not required for the project were deleted.

5.2 Coding Architecture

Based on the used electrical components, blocks were created to control the servo motor, the LED and to read out the status of the reed switch (Fig. 4).

Appropriate to the purpose of the servo motor, blocks were created which eventuate into movement generated by the servo motor. These blocks are called Forward, Left

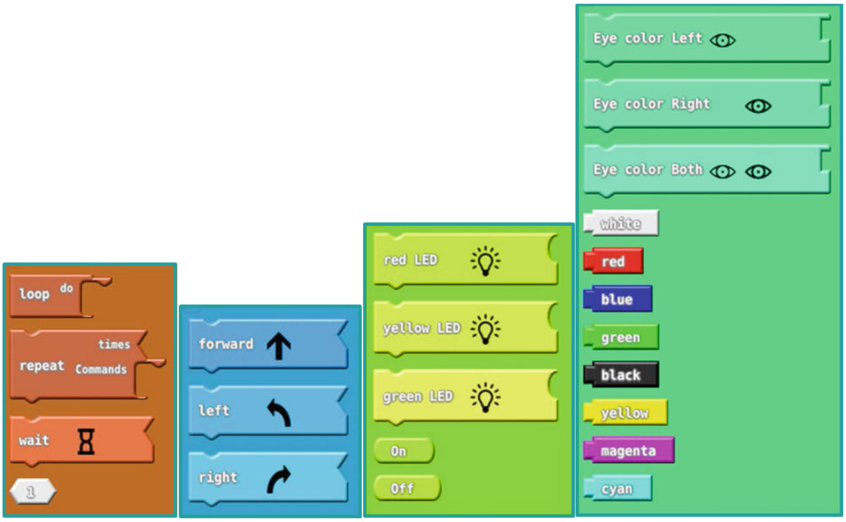


Fig. 4. Custom programming blocks to control the functionalities of Bubbles

and Right. To set how often this movement as to be repeated the blocks have a connector for Number. Also for the control of the Single Colour LED block were created. These blocks possess a connector for blocks containing a Boolean value. Corresponding to that, a block with On and a block with Off were created. Applying a single colour block with an On/Off block enables to turn the LED on or off. To set the colour of the RGB LED, a different operation system was developed. The RGB LED represents the eyes of the robotic fish. Because of that blocks were created which are called Left Eye, Right Eye and Both Eyes. These blocks have a connector for blocks containing a string of characters. To set the colour of the eyes, blocks were created with the name of the colours White, Red, Green, Blue, Yellow, Magenta, Cyan and Black. By connection a Colour block to an Eye block the colour of the RGB LED is set. Additional to the element which refers to electronic components, the basic programming elements Loop, Repeat and Wait were also created. The Repeat block possesses a connector for numbers which indicates how often the commands in this block have to be repeated. To set the time in seconds of the Wait block, a Number block can be connected to it. In order to create precise assignments, the blocks were coloured coherent regarding their category. The elements of the basic category are coloured orange red. Elements which are related to the movement category are coloured deep sky blue. For the categories of the single colour LED and RGB LED related colours were used. Single colour LED elements are medium spring green and RGB LED elements are spring green.

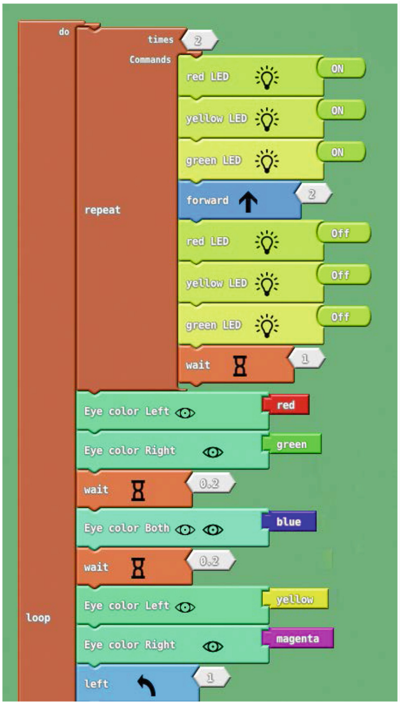
6 Final Prototype Testing

After the fish was assembled, all components soldered and connected to the correct points, it was verified that the robot works as expected, after being powered by the battery (Fig. 5). Concerning the final design, the body parts of the fish had to be cut down to the appropriate size and the holes increased to allow larger screws, attached to o-rings, to prevent water entering the inside of the robot. The team also used Vaseline, a waterproof substance, to further enhance the prototype waterproofing.

Finally, electrical calculations were performed for a 7.4 V /900 mAh battery to conclude that the charging time of bubbles would be around two hours. The battery life of the robot would allow it to be operated for over one hour, once fully charged.

Fig. 5. Photos of the final assembled prototype

In the sequel, a program example was developed using the Ardublock's blocks developed for the project (Fig. 6) The code was uploaded to the Arduino, and all components reacted as expected regarding the uploaded code. The Arduino Nano recognised the software that was developed and the program operates smoothly. In conclusion, once powered, bubbles operates as expected and the didactic robotic fish is set to be a fully functioning robot.




```
  pinMode(button, INPUT_PULLUP);
  pinMode(12, OUTPUT);
}

void loop()
{
  buttonWait();
  for (_ABVAR_1_a=1; _ABVAR_1_a<= ( 2 ); ++_ABVAR_1_a )
  {
    LED(true,"red");
    LED(true,"yellow");
    LED(true,"green");
    forward(2);
    LED(false,"red");
    LED(false,"yellow");
    LED(false,"green");
    delay(1*1000);
  }
  eyeLED("red",'l');
  eyeLED("green",'r');
  delay(0.2*1000);
  eyeLED("blue",'b');
  delay(0.2*1000);
  eyeLED("yellow",'l');
  eyeLED("magenta",'r');
  left(1);
  delay(0.2*1000);
  eyeLED("white",'b');
  delay(0.2*1000);
  eyeLED("cyan",'b');
  delay(0.2*1000);
  right(1);
  eyeLED("white",'l');
  eyeLED("black",'r');
  delay(0.2*1000);
  eyeLED("black",'l');
  eyeLED("white",'r');
  delay(0.2*1000);
  eyeLED("white",'b');
```

Fig. 6. Excerpted from Ardublock developed program and corresponding Arduino code automatically generated

7 Discussion

According to the EPS 10 Golden Rules [2], the EPS teams should be composed of students with different nationalities and backgrounds, as a way to foster the development of communication skills among individuals with distinct educational and cultural backgrounds and to instill a collaborative learning practice among team members. Therefore, in every edition of the programme, a set of projects with a strong focus in multidisciplinary is offered, so that each team member can contribute based on his/her previous knowledge and experience. An area that is usually appealing to students, inherently multidisciplinary, and which motivates students to collaborate during the learning process is the area of biological inspired robotics [14].

In the spring of 2016, an EPS@ISEP team chose to develop a Didactic Robotic Fish. The goal of this project is to design, develop and build an educational platform – the Robotic Fish – to initiate children in programming and robotics. In terms of requirements, the robot body should contain all electronic components, be printed on a 3D printer, and the system, as a whole, is supposed to have just one degree-of-freedom and be actuated by a single low cost RC servomotor. The controller must be inexpensive and easy to program and the programming "language" should be adequate for 10 year-old children. Finally, the information regarding how to build, assemble and use the educational platform should be public and available through a website both in Portuguese and in English, allowing replication and dissemination of the results.

The objective of this project is not to develop yet another prototype, but to make students learn to contribute, interact and converge towards a common solution. This process is not always easy, since students are not used to collaborate with students from different nationalities (implying distinct cultural backgrounds) and from backgrounds (engineering, business and product design). They need to learn to rely on each other and overcome communicational as well as technical and scientific challenges together as a team, while being autonomous and responsible.

The team started by performing a state of the art analysis regarding distinct solutions for the problem – in order to get inspiration and knowledge in the area. They analysed several swimming robot prototypes that have been developed and performed a comparative study of programming languages adequate for children. After brainstorming, the team agreed that, in terms of structural design, their body of the prototype will be based on two half-parts, which can be screwed together. The body will be hollow to accommodate all electronic components. Figure 1 shows the preliminary sketch of the prototype structure designed by the team.

In the sequel of this study, the students, motivated by the idea of turning the prototype into a product, identified their market niche and defined the marketing strategy, considering competitors and major stakeholders. Then, they analysed the sustainability, ethical and deontological concerns related to the design and development of the prototype as well as the manufacturing of the product. These tasks, which are not usually contemplated in this type of decision process, are demanding since students must integrate their disparate views in order to reach consensus. This approach provides an opportunity to develop communication, negotiation and collaboration skills together with technical and scientific learning.

In the words of the students, "*Throughout the duration of the EPS programme the team encountered many obstacles and without the support and excellent team working skills it would not have been possible to finalise bubbles. It was vitally important for the team to utilize planning skills to remain up to date with all of the expected deadlines and to ensure that the budget was analysed to remain within the amount that was provided. The EPS programme at ISEP allowed the team to grow stronger and it was important to learn and move on from any mistakes that took place. It also enabled team three the experience for any future projects that could be encountered in the future. Every person within the team has gained a much deeper insight into the engineering world as some classmates had no previous engineering experience, this again can enhance their knowledge and future career prospects. The EPS programme was a thoroughly enjoyable experience for the team as not only did people get to work and* *support people from across the world, bonds and friendships were also formed. Out with of the continuous study that took place, studying at ISEP enabled class mates to travel and live within a completely different culture, visiting the many historic and beautiful points of the city, trying different cuisine and enjoying all that Porto has to offer. The EPS programme allowed the team to explore a truly wonderful country that many would not have been able to do if they hadn't joined the programme.*

Although the creation of bubbles was a success, there is still always room for improvement and the team, through continuous work on the project could have potentially tackled certain situations differently. The initial plan was to construct a fish that would contain two fins and a tail but after more research, the team opted for the use of one sole tail. Furthermore, the initial product that was created was done so by a 3D printer, this could have involved more planning. Once the model was available to begin construction it was challenging to set up. This problem could have been prevented if the model was created to allow the top and bottom parts of the model to be directly connected to one another, saving the hassle of sanding and drilling larger holes in the model. Overall the project was a success and the creation of bubbles was one that was enjoyable, challenging and life changing."

The final product, while an educational platform, is expected to introduce children to robotics and programming and, thus, attract youngsters to the fields of Science, Technology, Engineering and Mathematics (STEM). In terms of outcomes, this learning process will provide the students with multidisciplinary teamwork experience in the design and development of a product, from requirements until the introduction of the product in the market.

8 Conclusions

Team three devoted and created a didactic robotic fish called Bubbles. Bubbles is essentially a toy for children but also provides educational learning in robotics environment. The robot was able to perform simple swimming motions as when place into water it could move to the right or to the left whilst being able to stay afloat. A simple programming language developed to operate the fish and allow the user, most likely young children, to be able to effectively use the controls. Significant research was conducted to monitor other projects and the real life movement of fish, thus leading to this design of the tail as it would mimic the movements of a real fish. Purchasing Bubbles will also provide the user with a user's manual to aid with the process of programming. The model that was constructed by team three is an exciting and cutting edge educational learning toy for children between the ages of five and ten years old. It has been created and advertised as an educational tool for everyone regardless of social status or backgrounds and for this to be achieved it will be sold at a fair and affordable price.

There were many obstacles that the team had to overcome as, first of all, each member of the group was from a different country. Therefore, communication was vital throughout the duration of the project to ensure each member fully understood the targets and what was expected. Team three worked as a collocated team to properly organize the work load and ensure everyone knew their specific jobs and tasks. As a team, everyone was supported fully to ensure this took place as without communication the creation of bubbles would have been impossible.

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Development of an Innovative Learning Environment for Engineering Education

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Abstract. In this paper a new concept for engineering education is being presented. It is the result of a study which consists of two parts and has the goal to create an innovative learning environment which increases the motivation and supports the development of competences of the students through job relevant, practical tasks.

The first part of the study comprises a redesign of a laboratory session, which is part of a Thermodynamics module. Thermodynamics is one of the core modules of mechanical and energy engineering degrees, dealing with very abstract concepts. To bridge the gap between theory and practical application a real-life problem should be integrated into the module. To do so, a laboratory session has been redesigned using a problem-based approach. In order to evaluate the new approach a longitudinal study was carried out at three different points in time. The results of this part of the study have been used in the second part of the study which is conducted as design-based research. This paper describes the first phase of the design-based research process resulting in the development of a prototype design for the new learning environment. In this design the university building is integrated in the education by creating an engineering consultancy where the students are the project engineers analyzing the energy supply system of the university building to identify energy saving measures. With this prototype design realistic tasks can be integrated in the education and competence development is being supported. The approach is a chance for future engineering education for sustainable energy use and helps to modernize engineering education.

Keywords: Competence development · Problem-based learning · Laboratory education

1 Introduction

With the rapid change in technology and the fast growth of available knowledge, the skills and competences expected of engineers today are also changing. In order to prepare students for the world of tomorrow, university education is moving away from knowledge transfer by lecturers towards a competence focused shaping, where learners are qualified to gain new knowledge, skills and proficiencies on their own. This process

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of change in the education system is marked by the shift from teaching to learning. Only graduates with these competences are in the position to master the complex adjustment processes that are required in a workplace today. In addition, as work requirements become more complex, individuals are experts on very specific topics only. That means experts have to work together more often in multidisciplinary teams in order to complete their tasks successfully. However, the project or cooperation partners may have different values, systems of thought, cultural backgrounds and experiences, often making collaboration a challenge. Hence, competences beyond expert knowledge are required, such as teamwork, cultural competences, organizational and communication skills, etc. A study of the German Chamber of Industry and Commerce points out that the companies' expectations regarding the graduates are mostly not fulfilled. The reasons for this are missing communicative and self-regulating competences as well as the difficulty graduates have to transfer theory into practice. It concludes that the German economy demands more application-orientation in their degree programs [1].

The resulting question for universities is: How can these complex requirements be considered in the academic education so that the students start to acquire the relevant professional skills and competences? [2] One didactic concept that provides a learning space to gain these required competencies is problem-based-learning (PBL) [3–5].

This paper describes how the focus on competence development is taken into consideration in the Bachelor degree program "Industrial Energy Engineering" at the Ruhr West University of Applied Sciences. The core learning outcome of this program is formulated as *"The graduates analyze technological or economical energy problems of medium complexity in a structured approach, applying the suitable theoretical knowledge and methodology. They evaluate their results and formulate appropriate recommendations."* The learning outcomes further state that the students can work effectively in teams and communicate the results of their work efficiently and appropriately. These complex intended learning outcomes are to be reached in a 7-semester degree program that includes a 20-week industrial placement near the end.

Seeing the need for modernizing traditional engineering education to allow for a focus on competence development, the goal of this study is to create an innovative learning environment which increases the motivation and supports the development of competences of the students through job relevant, practical tasks. In recent years, it has become more common to incorporate real-life problems in engineering education to increase student engagement. Students work on problems posed by partners from industry or the community (service learning), thus learning to apply their theoretical knowledge whilst at the same time knowing that there is real interest in their solutions. Research has shown that this learning with real and relevant problems or situations is one of five aspect to successfully engage students [6]. However, this approach leaves students and faculty staff dependent on the external partners. Experience at our own university has shown that difficulties arise in the accessibility of information from the external partners, agreeing on project timings in accordance with semester dates, and defining realistic project scopes.

It is thus the aim of this study to achieve a similar learning experience for the students without having to rely on external partners. This can be done by integrating the components of the energy supply system of the university building in the curriculum (living laboratory). Although there have been some approaches to do this in the past, there has not yet been an approach that achieved a sustainable integration of a university building into the curriculum of a degree program (see Sect. 4.3).

In a first step, the laboratory sessions of the thermodynamics module were changed to a more open ended approach using PBL and incorporating the university building. Thermodynamics is one of the core theoretical modules concerning the principles of energy engineering and at the same time it is found to be very difficult. Thermodynamic concepts are very abstract and intangible and students perceive the transfer of the theory to real-life problems to be particularly difficult. In order to aid this transfer, laboratory education is part of the module, as is the case for most other engineering modules. However, often the laboratory set-up itself is more or less removed from a real-life situation. Specially designed equipment that reduces complexity leads to easy to understand experiments but is removed from the equivalent real-life situation. As a result, students often fail to see the practical relevance of the given subject; this is especially true for fundamental subjects such as mechanics or thermodynamics. In addition, with these rather rigid laboratory set-ups students are likely to simply follow instructions without reflection rather than designing an experiment to answer a given question and reflecting on the results [7, 8].

For the thermodynamic module the laboratory sessions were thus changed to a more open approach to address these issues and to teach students typical engineering skills like designing experiments and interpreting data [9]. In addition, the intended overall program learning outcome to work in teams to analyze problems and evaluate the results with the appropriate methodology was to be addressed with a PBL approach.

Using both questionnaires and observations, the effect on student motivation and collaboration of the new laboratory sessions was assessed. The results form the basis for the development of a new learning environment that integrates the energy supply system of the university building.

2 Problem-Based-Learning

Problem-based-Learning (PBL) as a didactical method was developed at the McMaster University in Hamilton, Canada by Howard S. Barrows in the 70s and was originally used in medical education. The roots go back to the 1950s when dissatisfaction grew with the traditional medical education methods, in which the students were forced to paraphrase their lecturer in their exams [10].

Today PBL is a well-established concept at many schools and universities. Due to the possibility to define practical exercises at different levels of complexity and scope, a PBL task may be a short activating exercise but could also fill a complete course.

PBL describes a didactic method with specific characteristics: The basis is a complex and realistic question or task with an open result, where several approaches to solve the problem are permissible. The solution of the problem should require the students to both build on previous knowledge and to obtain new knowledge in the process. The students themselves decide how to reach a solution to the problem and are thus responsible for their own learning process. They decide on the questions that need to be answered, the methods to be used as well as the time frame. A PBL-exercise will always be solved in a team and communicative exchange is essential. The focus of PBL lies in the process of solving the problem rather than the actual result. The lecturer adopts the role of a 'learning mentor' who only emerges when the students are unable to progress without support. Last but not least, a critical reflection of the students' individual learning process and the teamwork is part of the didactic concept of PBL [11, 12].

A deep learning approach is achieved through the intense and autonomous work on a complex, practical and interesting problem embedded in social interaction [13]. Learners are motivated into an in-depth examination of the given subject matter as they construct their own knowledge and meaning. This self-constructed knowledge is memorized with a lasting effect [14–17].

In addition, Problem-based Learning enhances competences like teamwork, conflict management, self-monitoring, problem-solving and knowledge transfer demonstrably [18].

At the same time the authors found that PBL does not significantly increase overall satisfaction in comparison with traditional teaching concepts. Only when BPL is used throughout the degree course to large extent, an increased competence experience may be evidenced. In the study of Keller and Köhler [18], the competence experience of learners actually declined in the case of a medium-level implementation. This may be an indication that for learners, the experience of competence strongly depends on the acquisition of expert knowledge whereas the focus of PBL is on competencies required for general problem-solving and decision-making. A cross-disciplinary meta-study by Walker and Leary [19] arrived at the conclusion that students learning in PBL environments achieved comparable results to those learning with traditional educational methods and in some areas they are even better.

Overall, the research suggests that PBL may be less suitable for acquiring expert knowledge than traditional settings and favorable for communicative and interactive skills. The key for the successful implementation of PBL lies in the appropriate level of complexity of the problem with regards to the experience of the students. Both the time and the cognitive effort required for the solution must be considered when a problem is formulated by the lecturer [20]. Another crucial point for the success of PBL is the involvement of the tutor. He or she has to find the right balance between direction and laissez-faire since neither extreme facilitates the learning process [21].

With regards to the aim of this work to integrate the university building in the students' learning it is a challenge to formulate problems that are not too complex or do not need too much guidance by the lecturer.

3 Methodology

The work presented here consist of two parts: the first part comprises the redesign and evaluation of a laboratory session, which is part of a thermodynamics module, and the second part of the study is conducted as design-based research leading to the development of a new study course.

3.1 Laboratory Re-design

The laboratory sessions were redesigned in two different ways: A real-life problem regarding the energy supply system of the building was given one half of the students to investigate. Two different problems were given to the students; one concerned the decentralized cooling system of a meeting room, whilst the other involved the central ventilation system of the building. The other half was given a variety of relatively simple thermodynamic questions that were to be answered by designing and conducting their own experiment, similar to [9]. A detailed description of the experiments can be found in [22].

In both cases the students had to work on the problems in groups of five with supervision but minimal support from the course leader. The students were required to first formulate the question in such a way that an experiment could be used to find the answer. Next they had to devise an experimental design, including the experimental set-up, the values to be measured and the conclusions they were hoping to derive at. Only then were they permitted to actually set-up the experiment and perform the necessary measurements. The course leaders only intervened with guiding questions when it was really needed.

Each student of the industrial energy engineering degree program had one laboratory session with a traditionally guided experiment and one session with one of the new designs.

The initial hypothesis was that through more open and realistic laboratory questions the motivation both for the laboratory and for the complete module would be enhanced. At the same time it was thought that more introvert students, or those who have a higher fear of failure may find the new, more open laboratory problems more disconcerting. For these students it was thus presumed that there would be less of a positive effect on motivation of the new laboratory classes.

The evaluation was carried out with a questionnaire-based study that compared the student group subjected to the new laboratory designs to two student groups that were given the more traditional, rigid laboratory tasks.

Over the course of a semester, the students were questioned at three points in time; at the beginning of the semester, after their first laboratory session, and after their second laboratory session. As is common in Germany, the attendance dropped in the course of the semester, so that the test group comprised 40 students at the start of the semester but had reduced to 18 students when the last questionnaire was answered. The control groups started with 69 and 21 students and had reduced to 40 and 5, respectively, by the end. The questionnaires contained items regarding motivation (items from [23]) and personality (need for cognition and self-efficacy [24, 25], big five dimensions of personality [26]) as well as the students' experience during the laboratory session (usefulness, interest, relatedness, and flow (adapted from [27])). A detailed description of the study design including the results can be found in [22].

In addition to the questionnaires, observations were made by the course leaders during the laboratory sessions regarding the involvement of the individuals and the collaboration within the group.

3.2 Development of a New Study Course

This paper describes the first phase of the design-based research process resulting in the development of a prototype design for a new learning environment. In design-based research the design, development and evaluation of educational interventions is systematically analyzed, aiming "at advancing our knowledge about the characteristics of these interventions and the process to design and develop them" [28]. It is carried out in a cyclical way by first analyzing the context by literature review and site visits, second developing the first prototype design, which is then tested and refined in practice and third the development of design principles. It is important to report on the design-based research process through progress reports, articles etc., because the design evolves over time [29].

So far the context has been analyzed by a literature review of teaching approaches in engineering education with a focus on laboratory education (see [30]) and active teaching strategies like PBL (see above). Furthermore, an investigation was done to learn from other examples, where the university building is being integrated in the education of students. The results of these analyses and the results of the first part of the study regarding the laboratory re-design were taken into account leading to the creation of the first prototype design. This new course is being offered in the current semester and the implementation is being evaluated. The evaluation will lead to a redesign of the prototype, which will be offered in the coming semester.

4 Results and Discussion

4.1 Survey Results of the Laboratory Re-design

Regarding the overall motivation of the students, the main findings of the survey were that the students of all three groups are generally motivated because they see the personal relevance of their studies (identified motivation) as well as being intrinsically motivated. The Kruskal-Wallis test for independent samples showed no significant difference of the motivation as well as the big five dimensions of personality between the students of different degree courses. This suggests that learning activities designed for one group will be perceived similarly also by the other groups.

With regards to the perception of the new laboratory sessions for different types of students, it was analyzed whether the new laboratory sessions are evaluated differently by students having high or low need for cognition, high or low self-efficacy and having a high or low fear of failure. A number of items related to the enjoyment of the laboratory were merged into one indicator for the evaluation of the laboratory. This was correlated to need for cognition, self-efficacy and fear of failure, but for none of them a statistically significant correlation was found. A complete discussion of the analysis and the results can be found in [22].

To analyze whether the students perceived a difference in the two laboratory sessions the following items were analyzed: fun, usefulness, flow, integration and the wish for more laboratory session. For the test group these were compared between the eight respondents who answered after both laboratory sessions. If all answered questionnaires are taken into consideration the trend in the difference between the mean values is the same compared to the eight respondents, only for the item fun it is slightly higher for the old laboratory design than for the new one. As the sample size of eight is very low, no significance test was conducted. But the difference in the evaluation of the new and old design is very small with the old design scoring slightly better.

4.2 Observations of the Laboratory Re-design

For the new designs the supervisors of the laboratory sessions observed a more vivid discussion and more collaboration between students compared to traditional laboratory sessions.

As described before, some groups worked on two different tasks concerning a problem with the energy supply system of the building. For both tasks it was observed that students were at first unsure how to deal with the new situation. In case of the problem concerning the decentralized cooling system of a meeting room, the students solved the problem without major problems after this first hesitation. However, in the case of the ventilation system, the students struggled even though the underlying thermodynamic problem was the same. They were clearly confused because of the more complex system, struggling to identify exactly which parts of the system they needed to consider. The ventilation system has two separate heat exchangers, one for heating the air in winter and one for cooling the air in summer. Both groups struggled to work out that only ever one of those heat exchangers is active at any one time. This shows the difficulty and importance of designing a good problem. In this case, the intended emphasis was on applying the students' new thermodynamic understanding. However, since they had not yet had enough practice in dealing with complex systems, their attention was diverted away from the thermodynamics and it is questionable whether the intended learning outcome was achieved.

The observations during the research-type lab showed a similar behavior regarding the group dynamics and team work. Unlike during the more traditional labs, all students were actively taking part in the experiment. Particularly interesting was the resistance of all groups to actually plan and design their experiment before starting. Questions of the instructor were regularly needed to guide students to think about what they were trying to achieve before starting any measurements. The skills of phrasing a research question and also of questioning the measured data have yet to be developed. Hence, this type of lab is a very useful tool to train this and should be applied during the course of the studies more often.

In both types of new lab questions the students struggled with the transfer of the theory learnt in the lectures to a real situation. In the exercise sessions they managed to solve typical theoretical questions applying the first law of thermodynamics and the equations of state. However, during the lab sessions many failed to see the equivalence. The problem statement was less defined, thus requiring the students to first formulate a question that could be solved using their thermodynamic knowledge. In addition, they had to decide for themselves which parts of the apparatus were to be included in their system and what assumptions were reasonable to make. All of these thoughts are typical for the application of thermodynamics in the "real life", and thus important learning outcomes (see [1]). Since students find it so difficult, it is important that these types of learning activities are included regularly throughout the curriculum, which led the authors to the development of a new study course.

4.3 Development of a New Study Course

As mentioned above, it is the aim of this research that the university building is used as a 'living lab'. Using the campus building as a laboratory allows the integration of real-life problems and job relevant tasks into the curricula. For the context analysis, a literature review was carried out to identify other universities where the university building is being used for experiments by the students on a continuous basis (living laboratory). It was found out that there had been two living laboratories (one at the University of Colorado, Boulder and one at the Eastern Washington University) which both are no longer in use because of problems with maintaining the buildings' systems data (for more information see [30]). Two other, similar projects had been planned, but where not implemented. These findings stress the importance of a strategy for the sustained use of the prototype course design.

On the basis of the findings of the first part of the study, that it is hard for students to pose their own research question, to apply theory to practical problems, to treat measured data carefully and the fact that PBL based tasks increase the collaboration between students, it was decided to create a completely new study course. The prototype design for this course had to consider that the other living laboratories had problems with the sustainability of the project. Also the right complexity of the problem-task and the right balance in facilitation have to be considered when using PBL. As a result, a student engineering consultancy was created, which has the mission to contribute to the fight against climate change by analyzing the energy supply system and identifying energy saving measures at the university. The engineering consultancy simulates a small company where the students are the project engineers and the role of the director is taken by a lecturer responsible for the course. Students can choose to work for the engineering consultancy for one semester as an elective module.

The intended learning outcomes of the engineering consultancy course are the following: The students…

- …are able to explain the energy supply system of a building in general and of the university campus specifically;
- …are able to measure and interpret building systems data and to analyze differences between plan and operation;
- …evaluate the results and deduct energy saving measures from them;
- …include user's behavior in their analysis and are able to judge the impact of the suggested energy saving measures on the users' satisfaction;
- …engage constructively in the group work;
- …work in a timely manner;
- …document and present their work process and results so that they are understandable for third parties;
- …reflect on the working process and group work and deduce suggestions for improvement.

As can be seen from the intended learning outcomes of the new learning environment not only technical and methodical competences should be supported, but also social and personal competences. In order to be able to assess all intended learning outcomes a learning portfolio is chosen as assessment of the course. It consists of two parts: one is the documentation of the work process and results in such a way that following groups can build on these results. The other part is the individual reflection of the working and learning process. By giving the learning environment the frame of an engineering consultancy, meaning that there will be regular progress meetings with the director and regular working hours, some of the problems of PBL should be mitigated. Through regular meetings and the reflection of the students the lecturer can adjust the complexity if necessary. Through the simulation of real work situations the students are placed in the role of project engineers, thus being responsible for the analysis on their own with only minimal guidance by the director. This should make it easier for the lecturer to find the right balance in facilitation, because students do not have the attitude as in traditional courses that the lecturer has to present everything they should learn.

In order to achieve a sustainable use of the prototype design, the engineering consultancy has to be visible within the university. It is more likely that the project will continue after the current research project ended if there is a demand by the students to work in the consultancy. Therefore a marketing concept for the engineering consultancy is being developed at the moment. It builds on the following incentives for students to work there: they get credit points for one or two elective courses and they get a job reference and gain practical experience. Furthermore, there are meetings with the facility management and the university management board, so that the students see the relevance of their work.

This prototype design is being implemented at the moment. The evaluation concept was developed based on the experiences of the first part of the study. It consists of a mixed methods approach. The competence development is evaluated on the one hand through self-evaluation questionnaires which are being distributed at the beginning and at the end of the semester. To verify these results and to evaluate the motivation of the students, interviews are carried out at the beginning and at the end of the semester. In addition, observations are done by the lecturer and the results of the learning portfolios will be used to cross check the other results.

5 Conclusion and Outlook

This paper describes how competence oriented tasks can be integrated into engineering education. In the first part of the study a laboratory session of a thermodynamics module was redesigned. Through this students were led towards a working methodology of engineers and collaboration between the students was increased.

In order to integrate even more practical and job relevant tasks in the education a new learning environment has been designed in the second part of the study. The university building is integrated into the curricula by creating an engineering consultancy where the project engineers are the students who analyze the energy supply system of the university building in order to identify energy saving measures.

The engineering consultancy is being offered as an elective course. The intended learning outcomes for this new study course comprise not only technical and methodical outcomes, but also in the social and personal competence domain. A learning portfolio was chosen as a suitable assessment.

The first part of the study showed that it is not sufficient to evaluate a new design only by questionnaires if the sample size is small. That is why a mixed methods approach is used to evaluate the new learning environment. Questionnaires are being used together with interviews, observations and the results of the learning portfolio.

The new learning environment has the potential to modernize engineering education by building on the validated positives of PBL, yet applying it to real-life problems incorporating the university building.

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Active Pedagogy Project to Increase Bio-Industrial Process Skills

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Abstract. The main aim of this work is to develop the skills of our graduate students in creation and management of industrial projects from Research development laboratory work to the industrialization at pilot scale in bioprocess production. In this study, we initiate interdisciplinary project with students in three different specializations: research and application, process engineering and quality (30 students). The project subject is the production and industrialization of recombinant proteins.

Keywords: Active pedagogy · Interdisciplinary engineering · Project based learning · Bio-industrial process · Recombinant protein

1 Introduction

The teaching methodology evolution of sciences teaching is due to the change in students' profile and skills required by the industry to address interdisciplinary and complex problems with large amounts of information from different sources. Students in engineering should acquire skills in processing data, critical thinking, innovation, creativity, communication with various collaborators and project management [1].

Nowadays, we are assisting to the advent of active pedagogy. Apparently, these novel learning techniques are against the classic master-class teaching models based on rote memory and routine problem solving. These methods are learner centered to enhance interactivity, participation and adaptability [2].

According to our experience and research in pedagogy for engineering students, interdisciplinary learning associated with experimental learning develops and enhances skills required for engineering industrial projects [3].

The principal objective of this work is to improve interdisciplinary teaching for more efficient student skills by project work to catalyze creativity, critical thinking, collaboration and communication.

This work allows student's ability performance to analyze and synthesize research work with articles and to proposes their own approach to perform experimental work at

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laboratory and pilot scales, taking into account reagents and material needs, and communicate their results by articles and oral presentations.

Through this study, we have confronted our students to industrial issues, to achieve the project goals; they have to work cooperatively and synergistically, connecting their theoretical knowledge with practical ones.

The skills acquired in this pedagogical work correspond to industrial biotechnology needs around the process of recombinant protein production. The aim of this laboratory work is the production of interest recombinant protein in bacteria, Escherichia coli. Recombinant protein production is a biotechnological process which is used in different industrial fields: research, in-vitro diagnostics, pharmaceutical.

This laboratory work was included within the practical semester work module entitled Applied Biotechnology. This module forms part of the 5 year graduate studies for students of Research and development major of the School of Industrial Biology, Cergy, France: www.ebi-edu.com.

The course of this module focuses primarily on the new applications of advanced biology in different genomics industries. The aim is to provide in depth training on the tools and concepts required to carry out bioproduction projects.

The main research activity of the molecular biology department is centred on the biotechnology process: cloning and development of recombinant protein production and purification process.

The recombinant protein produced in this work is Pfu-DNA polymerase protein. Pfu DNA Polymerase is a highly thermostable DNA polymerase from the hyperthermphilic archaeum Pyrococcus furiosus.

This thermoresistant enzyme allows the DNA polymerization at 72 °C with high fidelity and is used to amplify DNA by polymerase chain reaction technology (PCR), for genetic analysis, sequencing and molecular cloning. Most native thermostable enzymes are synthesized at very low levels by the thermophilic bacteria and are therefore cumbersome to purify. To overcome the low yield of natural Pfu protein production from wild thermophilic bacteria, the heterologous expression and production in recombinant form of this DNA polymerase was developed in *E.coli*. The recombinant Pfu-DNA polymerase has a great interest in biological research laboratories.

E.coli is one of the most widely used hosts for the production of the heterologous protein, because of its ability to grow rapidly, its well characterized genetics, high-density cultivations, and the large number of mutant host strains and compatible cloning vectors available for biotechnology [4]. It was the first host used to produce recombinant therapeutics proteins (human insulin in 1982) and continues to dominate the bacterial expression systems [5].

The fusion tag technology has been extensively used for recombinant protein production and purification [6]. Affinity purification tags, such as polyhistidine tag and streptavidin/biotin derivative systems, have become indispensable fusion partners for easy purification or immobilization of proteins [7–9]. Fusion strategies using marker tags have emerged in monitoring process. To accelerate the optimization of both expression and purification steps we previously developed and reported the design of a Colored Multi-Affinity-Tag (CMAT) which contains a colored marker cytochrome b5 and two affinity purification tags: 10HIS (histidine) and SBP (streptavidine binding protein) for an easy monitoring of production and purification process [10].

2 Methodology

2.1 Padagogical Methodology

The methodology of this study is based on the project realization from the idea to the real product, using different approaches of recombinant proteins research, development and industrialization. The graduate students received the project specifications of recombinant protein production.

The students work is organized in different phases: bibliographical analysis, approach proposition required in the production of the interest recombinant protein in laboratory and pilot scales, tests and experiment realization and finally communication of their results.

In this work, the students have studied the efficiency production of two forms of recombinant Pfu (6His-Pfu, CMAT-Pfu) in two strains *E.coli*. (KRX-tRNA rare, BL21-AI-tRNA rare). Students can understand the steps required for production and purification of recombinant proteins process and its optimizations. Figure 1 below illustrate the general project flow chart.

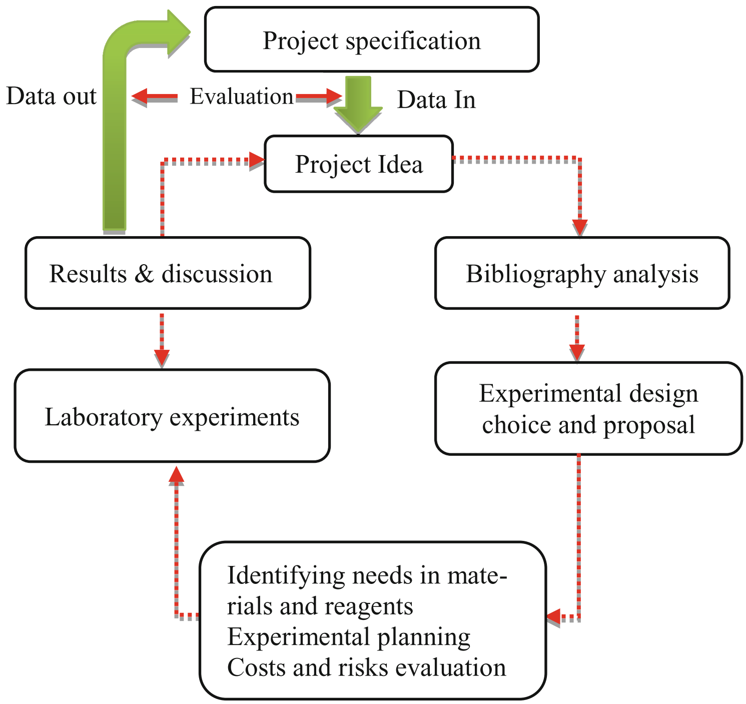

Fig. 1. Pedagogical frameworks of students' recombinant protein project

- Bibliography analysis
  The ability to review, and to report on relevant literature is a key engineer skill. Students analyze and summarize several scientific articles about production, purification, characterization and activity of Pfu protein. At the end of this stage, students have a fairly detailed information about all properties of this protein at any point of view.
- Experimental design
  After this literature review, students are able to perform a critical analysis and propose an experimental methodology to achieve the desired production, taking into account various constraints raised by the literature. Methods of production, purification and characterization are identified.
- Identifying materials and reagents needs
  Students identify specifically equipment and reagents required to perform this protein production at each stage. We ask students to specify precisely production equipment in our laboratory and make calculations of cost based on the cost of reagents.
- Laboratory experiments
  Once Students identify and select equipment and reagents, they design experiments in a protocol.
  Following the completion of the protocol, the next step, students have to set up all the experiments and make up all the solution, taking into account the critical parameters of recombinant protein Production and purification.
- Results and discussion
  For each step of project from production to activation test, students collect data, analyze and interpret their results. Students deduct the influence of various parameters on the production process, results are compared to the literature.
- Management and evaluation
  We establish an overall project schedule with deadlines, milestones and dates for project reviews. Students give for each stage a report. We evaluate projects on both quality of reports and oral presentation, based on several criteria:
  - Motivation
  - Bibliography analysis
  - Experimental design
  - Laboratory experiments
  - Quality of results
  - Interpretation
  - Communication

2.2 Experimental Methodology

2.2.1 Materials and methods

Materials

Pipettes and micropipettes, Eppendorf tubes, incubator orbital shaker, chromatographic column, laboratory centrifuges, ultrasonicator.

Reagents

Reagents including tryptone, yeast extract, ampicillin, chloramphenicol and agarose were purchased from Euromedex (Souffelweyersheim, France). DNA polymerase, TA Cloning kit, and gel electrophoresis were bought from Invitrogen (Carlsbad, USA). T4 ligase, oligonucleotides for gene amplification, Isopropyl β-D-1thiogalactopy-ranoside (IPTG), δ aminolevulinic acid, Imidazole and molecular weight markers were purchased from Sigma (Missouri, USA). Enzymatic quantification reagent bicinchoninic acid (BCA) were from Thermo Scientific (USA). Streptactin column was purchased from Novagen and NI-NTA agarose from Sigma (Missouri, USA).

Expression vector pET15b His and pET15b-CMAT used for the production of the recombinant Pfu was previously developed in our laboratory. E. coli strain Top10F′ (Invitrogen, USA) was used as the recipient of all subclonings.

Strains

BL21 AI tRNA rare (ThermoFicher france), KRX tRNA rare were used for the Pfu expression and production studies.

Methods

Protein Expression and production

E. Coli BL21 AI tRNA rare and KRX tRNA rare strains transformed with the recombinants plasmids was cultivated overnight on LB agar plate containing 100 µg/ml ampicillin and 34 µg/ml chloramphenicol at 37 °C. A starter culture (10 ml) prepared from one isolated colony was used to inoculate 100 ml of fresh LB medium supplemented with ampicillin and chloramphenicol. When the cultures reached an OD600 nm, inducers were added to exponentially growing cells according to the Table 1 below.

Table 1. I. Induction conditions

Recombinant strains	Inducers
KRX-tRNA rare/pET15-6His-Pfu	1 mM IPTG + 0.2% Rhamnose
KRX-tRNA rare/pET15b-CMAT-Pfu	1 mM IPTG + 0.2% Arabinose
BL21-AI-tRNA rare/pET15b-6His	1 mM IPTG + 0.2% Rhamnose + 2 mM δ aminolevulinic acid
Bl21-AI-tRNA rare/pET15b-CMAT	1 mM IPTG + 0.2% Arabinose + 2 mM δ aminolevulinic acid

Protein extraction and purification

The cultures were grown 4 h at 37 °C and 225 rpm. The bacterial growth and the expression monitoring of fusion protein CMAT-Pfu were measured respectively at 600 nm and 400 nm (OD cytochrome b5).

At the end of induction, cells were harvested by centrifugation at 4000 rpm for 15 min (4 °C) then washed with PBS. To extract the intracellular proteins, the cell pellet was re-suspended in phosphate buffered saline (PBS), pH 7.4 and 0.5% Triton

X-100 supplemented with a protease inhibitor cocktail (Roche Diagnostics, Germany) and disrupted by ultrasonication in iced water.

The different form of recombinant Pfu were purified by affinity chromatography on Nickel resin.

BCA protein quantification

The total protein amounts and the purified samples were determined using a BCA assay kit.

Protein analysis: SDS page

All protein samples (total proteins and purified fractions) were analyzed by SDS Polyacrylamide gel electrophoresis.

Pfu activity test

The activity of two types produced Pfu were tested and compared to commercial Pfu by PCR.

3 Results

3.1 Experimental Results

This experimental student's studies focus on how to apply their molecular biology, biotechnology and process knowledges to rationalize and perform recombinant protein production in a laboratory scale and understand the critical parameters required to the industrial scale, taking into account the hosts cells used in this area.

In the present work both the His-Pfu and the Pfu fused to CMAT have been produced in *E. Coli* BL21 AI tRNA rare and KRX tRNA rare strains. Two types of affinity chromatography purification were used: His-tag and SBP.

In Purification step based on His-tag, the His-Pfu and CMAT-Pfu were performed on NiNTA-resin column. Obtained results shows the solubility of the two recombinant proteins. His-tag Pfu at 90 kDa (Fig. 2-A) and CMAT-Pfu at 115 kDa (Fig. 2-B).

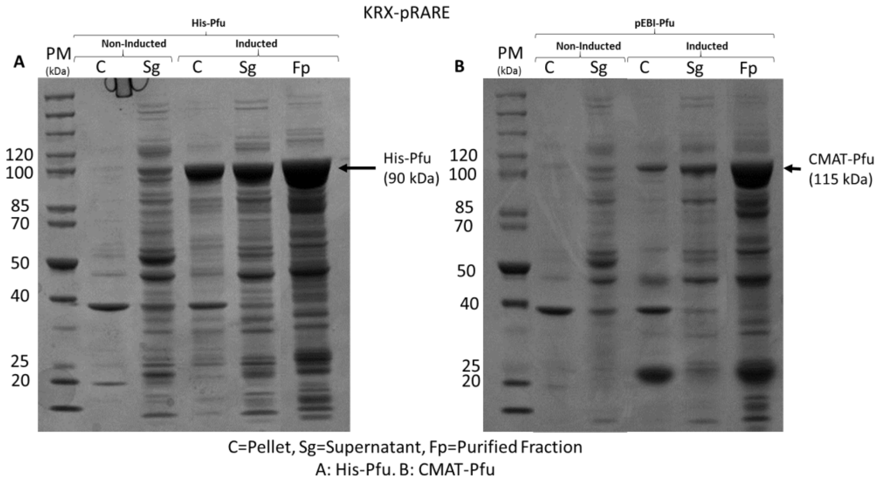

Fig. 2. Protein fraction SDS-PAGE analysis, A: His-Pfu, B: CMAT-Pfu

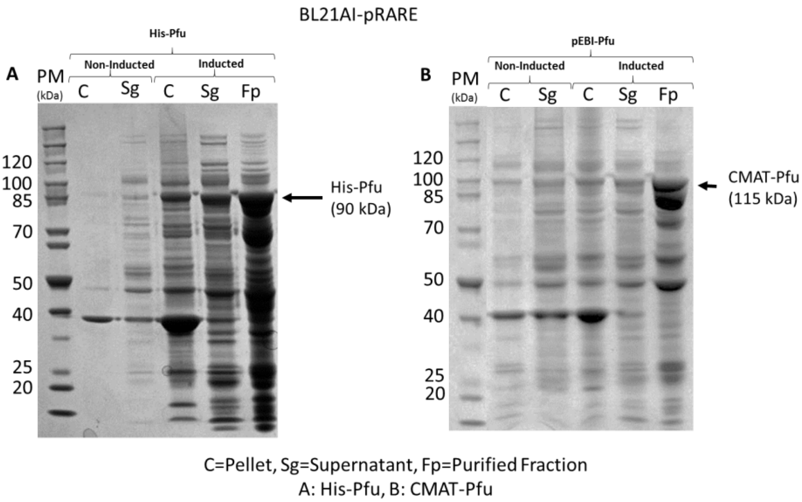

Fig. 3. Protein fraction SDS-PAGE analysis, A: His-Pfu, B: CMAT-Pfu

The KRX strain shows higher expression than BL21.

Purification affinity chromatography based on nickel resin shows the presence of contaminant bacteria protein (Figs. 2-fp, 3-fp, and 4-fp1), this purification can be optimized by more stringent washing, but often gives contaminant.

The double affinity chromatography via two tags affinity His-tag and SBP-tag allows a high degree of purity of CMAT-Pfu (Fig. 4-Fp2). The production yield of this students work is around 2,7 mg CMAT-Pfu in 200 mL culture (KRX strain).

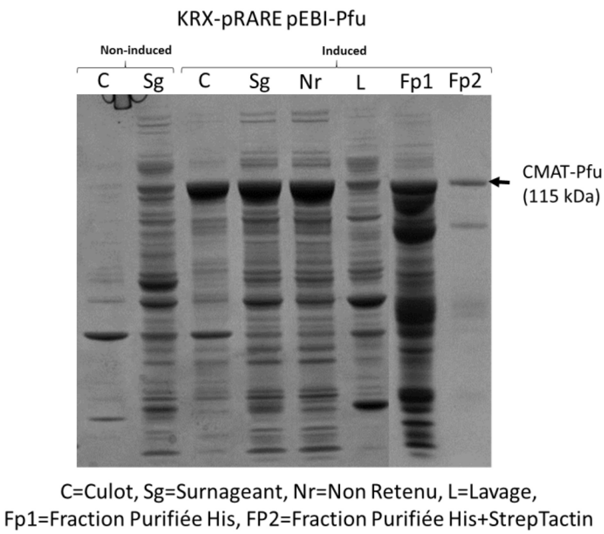

Fig. 4. Protein fraction SDS-PAGE analysis

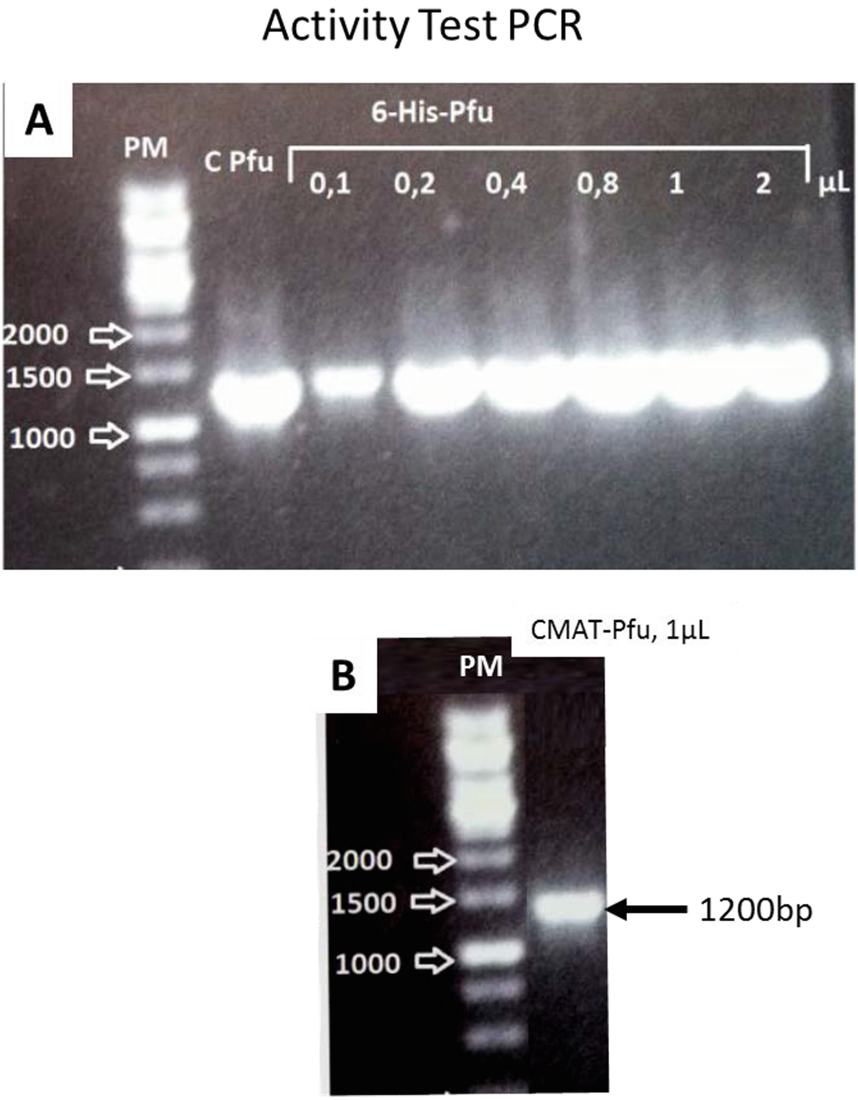

Fig. 5. PCR test activity: A: 6His-Pfu PCR amplification, B: CMAT-Pfu PCR amplification

In order to validate the activity of the two Pfu forms, His-Pfu and CMAT-Pfu, DNA fragment (1200 bp) amplification was performed by PCR. The results show the amplification of interest fragment with expected molecular weight using 6His-Pfu (Fig. 5-A) and CMAT-Ffu (Fig. 5-B).

3.2 Pedagogical Results

The main objective of this educational approach is to instill a culture of working on a multidisciplinary project with input data in contact with a large amount of information coming from several sources.

With this approach, we want to increase student's technical skills in recombinant protein production process. Additionally, the students are required to broaden their field of competence to the management and industrialization of production.

Moreover, their skills in information synthesis, communication and collaboration are also improved.

Furthermore, we have seen a remarkable increase in the involvement and motivation of our students during this project.

All reports are presented in a classroom session by student teams. Discussion of their own results and the project specifications helps students to appreciate the role of each stage in recombinant protein process.

4 Conclusion

Through this work we have introduced a pedagogy by interdisciplinary project with the main theme of Pfu protein production process. Our goal is the students acquisition of technical skills in a multidisciplinary environment. They develop by themselves the production process from the specifications imposed by the teachers to the final product.

We noticed a great involvement of students for this project with a strong motivation.

Solving problems, upstream and downstream process allowed acquiring technical expertise in recombinant protein production area in bacteria expression system with critical parameters: (1) production process, (2) purification methods, (3) analytical methods, (4) activity tests and (5) purified recombinant protein quality.

This project confronts students with the use of all their knowledge in different fields to solve problems and propose appropriate solutions to achieve the goals of the project.

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Entrepreneurship Certification Concept for Higher Technical Colleges in Austria

Goals and First Experiences

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Abstract. The Austrian federal working group "Entrepreneurship for Engineers" established a certification concept for Higher Technical Colleges. School sites as well as students may obtain a certificate, awarded by IGIP, if they confirm the activities and the commitment towards Entrepreneurship Education.

Keywords: Entrepreneurship · Certification

1 Background

Referring to the Lisbon strategy for growth and employment, Europe needs to stimulate entrepreneurial mindsets among young people, encourage innovative business start-ups, and foster a culture that is friendlier to entrepreneurship and to the growth of small and medium-sized businesses. The important role of education in promoting more entrepreneurial attitudes and behaviors is widely recognized. The Spring European Council of March 2006 underlined the need for a positive entrepreneurial climate as well as for framework conditions that facilitate and encourage entrepreneurship. Member States were also invited to introduce greater measures, including entrepreneurship education. Following the European Conference in Oslo in October 2006, which presented a wealth of examples of good practice, the Commission published the 'Oslo Agenda for Entrepreneurship Education in Europe'[1].

Developing and promoting entrepreneurship education has been one of the key policy objectives for the EU and Member States for many years. In the context of high youth unemployment, economic crises and rapid changes linked to our complex knowledge-based economy and society, it would appear that transversal skills, particularly entrepreneurship, are essential if young people are to become active, creative and entrepreneurial citizens.

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[1] Available at: http://ec.europa.eu/enterprise/policies/sme/promoting-entrepreneurship/education-training entrepreneurship/index_en.htm.

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At national level, there are different levels of engagement. Some countries have already been committed for more than a decade, while others are just beginning to address entrepreneurship education as part of their education policies[2]. The European Commission supported the development of entrepreneurship education for a long time. In its “2012 Communication Rethinking education: Investing in skills for better socio-economic outcomes”, it emphasizes transversal skills and particularly entrepreneurial skills and recommends that Member States should foster entrepreneurial skills through new and creative ways of teaching and learning on the opportunity of business creation as a career destination. Real world experience through problem-based learning and enterprise links should be embedded across all disciplines and tailored to all levels of education. All young people should benefit from at least one practical entrepreneurial experience before leaving compulsory education’[3].

In 2014, The Council adopted conclusions on entrepreneurship in education and training, stressing that developing an entrepreneurial mind-set can have considerable benefits for citizens in both - their professional and private lives.

2 Entrepreneurial Mind-Set

Entrepreneurship is a skill that can be learnt. You don’t have to be born as an entrepreneur to run a successful business. You can become one by developing an entrepreneurial mind-set and working on your entrepreneurship skills. As Europe needs more entrepreneurs, who generate jobs, it is necessary to support this type of education in all EU countries. Young people with entrepreneurship education are more likely to set up their own companies than those without. Up to 20% of the students who participate in a mini-company program in secondary school will later start their own company. That is up to five times higher than in the general population.[4]

Entrepreneurship education prepares people to become responsible and enterprising individuals. It helps people to develop the skills, knowledge, and attitudes necessary to achieve the goals they set out for themselves. Evidence also shows that people with entrepreneurial education are more employable.

Entrepreneurial mind-sets and skills can be:

- effectively built only through hands-on – or real-life experiences, and project work;
- taught across all subjects as a separate subject or combined with another;
- important for ‘entrepreneurs’ who fulfil the role of entrepreneurs, leaders, and innovators within a group or organisation;
- promoted beyond educational institutions to businesses and the wider community.

[2] EACEA/European Commission (2012); McCoshan, A. et al. (2010).

[3] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions on Rethinking education: Investing in skills for better socio-economic outcomes, COM/2012/0669 final.

[4] Source: European Commission/Growth/Entrepreneurship and SMEs/Support we provide/ Entrepreneurship education.

3 Entrepreneurship Education at Austrian Technical Colleges

Entrepreneurship education is part of the national curricula of the Austrian Technical Colleges (ISCED 55). A variety of different compulsory subjects provides basic entrepreneurship education aspects in the curricula[5]. In addition to that, all curricula offer an optional school subject, which provides specified and focused entrepreneurship education. The decision if this subject is offered has to be made by the school – management.

The Austrian Federal Ministry for Education established an expert group in 2010 to encourage and foster entrepreneurship education at the Austrian Technical Colleges. The main objective of the expert group is to support and promote all entrepreneurship related school activities.

At the Austrian Technical Colleges creative and innovative teachers meet young interested students with excellent ideas for marketable products and services. Teachers for technical subjects need to have at least a university degree and four years of working experience before they start their teaching career. That is why it can be assumed that they are more likely to share their own personal experiences with the students, which can foster understanding topics like entrepreneurship. “Entrepreneurship Education” should motivate, help and lead students and teachers to design thinking and product development.

In order to create a better common understanding of Entrepreneurship Education at the Austrian Technical Colleges, the expert group provided the “EfE-Guide”[6]. This guide provides all relevant information concerning the Entrepreneurship Strategy at the Austrian Technical Colleges, e.g. different entrepreneurial competences that should be taught as well as the program for the teacher training.

4 Federal Working Group “Entrepreneurship for Engineers” for Higher Technical Colleges in Austria

The Austrian Federal Ministry of Education established a federal working group “Entrepreneurship for Engineers” (Entrepreneurship Education at Higher Technical Colleges) in 2010. Members of this working group are teachers from all nine federal states in Austria, in total they are 15 persons.

In the first years the activities of this working group resulted in several initiatives, e.g.:

- Development of an “Entrepreneuship for Engineers” guide.
- Describing the tasks, goals and organizational structure of the working group, the competences of an entrepreneur and educational goals in teaching entrepreneurship subjects.

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[5] Available at: BGBl. II Nr. 262/2015.

[6] Source: http://www.htl.at/htlat/schwerpunktportale/entrepreneurship-for-engineers.html.

- Establishing an online platform at www.htl.at: A possibility to share information for teachers in Higher Technical Colleges
- Offering several "Entrepreneurship for Engineering" seminars at pedagogical colleges, which featured methods and tools for innovation and creativity in entrepreneurship.
- Assistance at the establishment of Junior Achievement companies.
- In Europe more than 30.000 schools, with the help of 115.000 teachers and 160.000 business volunteers use this initiative to empower more than 3 million students across 39 countries (Source: http://www.jaeurope.org/, July 2016).
- and further more

The Austrian Higher Technical Colleges define their concept of "Entrepreneurship Education for Engineers" as follows: Entrepreneurship Education for Engineers includes …

- .. the usage of the technical and technological know-how of their students (their abilities to design and build products)
- .. the extension of a basic, fundamental economic knowledge
- (These two points mean strengthening their professional skills.)
- .. the establishment and increasing of methodological competences, especially in the areas of innovation & creativity
- .. the enlargement of these skills with social and personal skills
- (teamwork, project management, self-confidence or power of persuasion, …)

The most important objectives of entrepreneurship education - Entrepreneurship for Engineers – in vocational technical schools are

- to awake the students' enthusiasm to believe in their ideas and
- to motivate them to work on these ideas.

5 Certification Concept/Model "Entrepreneurship for Engineers" for Higher Technical Colleges in Austria

In order to ensure that the entrepreneurship activities of the school sites are realistic, practice-oriented and scientifically justified, it was decided that several institutions work together, both in the certification process, as well as during the audit of the school sites.

The following stakeholders form the set of organizational units for the certification process:

- Certification organization (unit): IGIP - International Society for Engineering Pedagogy): IGIP is responsible for the definition and compliance of the process and the granting of certificates
- Scientific partner (unit): Graz University of Technology, Austria
- Operational unit: Federal Working Group Entrepreneurship for Engineers (Austrian Federal Ministry of Education)

- Quality Assurance (unit): An Entrepreneurship for Engineering "sponsor/godparent": an experienced entrepreneur, who has to accompany the school site over the whole schoolyear
- Auditing group (unit): 4 Members from
  - the Federal Working Group Entrepreneurship for Engineers
  - the scientific partner (University of Technology Graz)
  - the certification unit (IGIP)

After a successful audit the school site receives the Certificate "Competence Center for Entrepreneurship Education in Engineering certified by IGIP" and the school is allowed to certify their students within the valid time frame of three school years.

Following this procedure two Entrepreneurship for Engineering certificates – for the two target groups - have to be distinguished and defined:

- Certificate for the school site
- Certificate for the students

For both target groups – the school site and the students - criteria for the Entrepreneurship for Engineering certification have been defined. The criteria for the school site are also subdivided into criteria for the school management and teachers and criteria for the Entrepreneurship for Engineering godparent.

1. certification criteria for the school site
   (a) certification criteria for the school management and the teachers
   (b) certification criteria for the Entrepreneurship for Engineering sponsor/godparent
2. certification criteria for the students

In both lists of mandatory criteria and optional criteria are classified. All mandatory and a defined number of optional criteria have to be fulfilled within a school year.

6 Certification Criteria

6.1 Certification Criteria for the School Management and Teachers

Mandatory criteria for the school management & teachers

- M1: Entrepreneurship education as part of the school mission statement (Quality Management)
- M2: Naming Entrepreneurship for Engineering contact persons
- M3: Entrepreneurship for Engineering sponsorship (godparent-hood) with an Entrepreneur (a company)
- M4: Holding an Entrepreneurship for Engineering Event ("EfE-Day") at the school site during the school year
- M5: Offering the optional subject "Entrepreneurship for Engineering" or a comparable optional subject
- M6: Establishment of at least one Junior Achievement company
- M7: Attending Entrepreneurship for Engineering relevant competitions
- M8*: Visualization of the Entrepreneurship for Engineering activities (only for re-certification)

Optional criteria for the school management & teachers

- O1: Internal Entrepreneurship for Engineering -trainings & further education on the school site for teachers
- O2: Attending Entrepreneurship for Engineering seminars at pedagogical colleges
- O3: Completion of at least one Junior Achievement company
- O4: Attending networking meetings of the federal working group Entrepreneurship for Engineers
- O5: Presentations by entrepreneurs at the school site
- O6: Assistance activities for IGIP or for the federal working group Entrepreneurship for Engineers
- O7: Additional Entrepreneurship for Engineering activities outside regular classes (subjects)

6.2 Certification Criteria for the Entrepreneurship for Engineers Sponsor/Godparent

Mandatory criteria for the godparent

- M1: signed Entrepreneurship for Engineering sponsorship (godparent-hood)
- M2: lectures on Entrepreneurship for Engineering topics at the school site
- M3: Active participation at the Entrepreneurship for Engineering Event ("EfE-Day") of the school

Optional criteria for the godparent

- O1: Supervision of Entrepreneurship for Engineering initiatives and projects from students
- O2: Participation in teacher-training
- O3: Involvement in Entrepreneurship for Engineering related lessons at the school

6.3 Certification Criteria for Students

Optional criteria for the students

- O1: Participation in the optional subject "Entrepreneurship for Engineering" or a comparable subject
- O2: Participating in an Entrepreneurship for Engineering relevant competition
- O3: Presentation of a business idea, a business model or business plan as part of the Entrepreneurship for Engineering Event (EfE-Day) at school
- O4: Member a completed Junior Achievement company
- O5: Diploma thesis with Entrepreneurship for Engineering related content

Three out of these five criteria have to be fulfilled from a student to receive the certificate. The certificate will be awarded with the final diploma.

7 Summary

The presented Entrepreneurship for Engineers certification process and the audit have been tested successfully at the HTL Wolfsberg in Austria in the last school year.

The authors hope that this concept for a certification model in the field of Entrepreneurship for Engineers, will help to stimulate the entrepreneurial mind-sets among young people, especially at Higher Technical Colleges in Austria.

Students will learn and work for their own future.
“Let’s bring ideas into action”

Role of Project Based Learning in Education

Case Study of Young Enterprise Northern Ireland

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Abstract. The role of project based learning in creating a modern education system is explored, making use of the Junior Achievement – Young Enterprise methodology as a case study. Through the 'Company Programme', students start up and run their own business over an academic year, developing skills for employment and entrepreneurship.

Keywords: Junior achievement · Project based learning · Entrepreneurship · Start up

1 Introduction: Education and Skills Landscape

The role of education is changing. There is a shift in education from teaching to facilitation; from transferring facts and information, to enabling young people to critique the vase amount of information that is now available to them via the internet; a move from 'traditional' education focused on a 'chalk and talk' methodology, to one which encourages young people to challenge ideas and develop skills.

Ken Robinson & Lou Aronica in 'Creative Schools' (2015[1]), observed of the current education system, "These systems were developed in large part to meet the labor needs of the Industrial Revolution and they are organized on the principles of mass production. The standards movement is allegedly focused on making these systems more efficient and accountable. The problem is that these systems are inherently unsuited to the wholly different circumstances of the twenty-first century."

As we develop a knowledge based economy, a different approach to education is required in order to develop what are known as 21st century skills. Education has a critical role in the development of these skills, using a different approach in order to gain different outcomes.

The European Commission notes that "Attention should be particularly focused on the development of entrepreneurial skills, because they not only contribute to new business creation but also to the employability of young people."[2] It goes on to state

1 Ken Robinson & Lou Aronica, 'Creative Schools', 2015.

2 'Rethinking Education: Investing in skills for better socio-economic outcomes' Communication from the Commission to the European Parliament, The Council, The European Economic & Social Committee and the Committee of the Regions, COM (2012).

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that, "Member States should foster entrepreneurial skills through new and creative ways of teaching and learning from primary school onwards, alongside a focus from secondary to higher education on the opportunity of business creation as a career destination."

This requires a significant shift in approach for education policy and traditional methods of learning and teaching. The system of education needs to support this method of learning, which operates outside of the traditional testing of learning approach.

2 The Northern Ireland Policy Context

The Northern Ireland Educational Curriculum[3] (2007) for Primary and Post Primary education has responded to this environment and need for a skills based environment by establishing a skills based curriculum, that requires the development of 21st century skills at its core.

The Curriculum at Key Stage 4 has the objective 'to develop the young person as a contributor to the economy and the environment' (Department of Education Northern Ireland), and also identifies the need for skills development at earlier stages. This includes aspects of Career Planning, Entrepreneurship, Employability and Active Enquiry-Based Learning.

The Northern Ireland Executive Innovation Strategy[4] (2014) recognises that 'skills such as entrepreneurship, risk and creativity… can be developed throughout the education lifecycle' and the work of Young Enterprise is a testament to the development of these skills at this stage. We would suggest that Young Enterprise flagship programme, "Company', is a best practice model of how this can be achieved, and would encourage schools be supported in taking up the programme as an in-curricular activity, to support the development of these skills.'

3 Case Study: Young Enterprise Northern Ireland

Young Enterprise is Northern Ireland's foremost business and enterprise education charity, helping young people find and develop their entrepreneurial spirit. Young Enterprise is a company limited by guarantee with charitable status, founded in 1986 and established independently in Northern Ireland in October 1997. It operates under license from Young Enterprise UK, and is part of the Junior Achievement – Young Enterprise network.

Over 90,000 young people aged 5–25 each year engage in enterprise and entrepreneurship education activities, with the support of volunteers from the business community. Young Enterprise's flagship Company Programme enables over 1,500

[3] Northern Ireland Curriculum, Council for the Curriculum, Examinations and Assessment, 2007.

[4] Innovation Strategy, Northern Ireland Executive, 2014.

15–19 year olds to run their own real companies for a year with help from business mentors. Many of the scheme's alumni have gone on to outstanding business success.

Using this experiential learning methodology, Young Enterprise supports the school curriculum adding to student employability. Evidence shows that a greater focus on pre-enterprise education aimed at providing a strong linkage between the reality of business and the classroom directly affects employability. The European Commission report on Mini-Companies in Secondary Education[5] highlighted activities where students run a mini-company at school as an effective methodology for spreading entrepreneurial mindsets, as it is based on learning through direct experience of entrepreneurship, and supports the effectiveness of these programmes in tangibly promoting the entrepreneurial spirit of young people. It is positive that the Northern Ireland Curriculum provides the opportunity for students to learn about life and work, and develop transversal skills.

This 'learning by doing' methodology supports the measures to develop and hone the skills to support innovation, equipping future employees in all sectors and graduates of all disciplines with 21st century workplace skills, to create 'intrapreneurs' who work creatively within business, as well as entrepreneurs.

The European Commission Key Competences for Lifelong Learning European Reference Framework document[6] highlights 'a sense of initiative and entrepreneurship' as a key competency. This includes 'creativity, innovation and risk-taking, as well as the ability to plan and manage projects in order to achieve objectives'. In order to develop an innovative future workforce, it is vital that all young people and employees develop these skills, not just those studying in the STEM field. The experience of setting up and running their own company, taking on management roles in marketing, production, and sales, allows young people to take on responsibilities and learn from both positive and negative experiences in a controlled risk environment.

Amongst business-owning alumni, Young Enterprise was ranked as the most significant experience they drew upon when establishing and building their venture. Compared to the Control Group, Young Enterprise alumni were better able to see the relevance of school work to their future.[7] Increased investment in schemes such as the Young Enterprise – Junior Achievement Company Programme, and adaptation to a range of disciplines outside of business, can help build a greater appetite for school-age young people to start their own business in the future. The evaluation found that participation in the Young Enterprise Company Programme is the most significant experience in helping young people to develop key business and life skills whilst in education. At the initial stages of their career, alumni felt better equipped with the necessary skills to make a start on their working lives than the Control Group.

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[5] European Commission: Mini-Companies in Secondary Education, Best Procedure Project: Final report of the Expert Group - http://ec.europa.eu/enterprise/policies/sme/files/support_measures/training_education/doc/mini_companies_en.pdf.

[6] The *Key Competences for Lifelong Learning – A European Framework 2006 (Official Journal of the European Union* on 30 December 2006/L394*).*

[7] Fresh Minds Research findings: http://bit.ly/pCpFnz.

4 Conclusion

It is important in the development of policy that consideration is given to the development of enterprise education within schools as enterprise education is considered a basic enabler for building an entrepreneurial economy. The 2011 Overseas Development Institute report on 'Maximising impact of youth entrepreneurship support in different contexts[8]', identifies 'entrepreneurship education at primary, secondary and post-secondary level as the basic requirements, that need to be met to facilitate entrepreneurship'. It goes on to "identify R&D transfer and business sophistication as innovation enhancers required to enhance the level of innovation and sophistication among entrepreneurs. Innovation enhancers are more likely to be a truly binding constraint after the basic- and efficiency enhancers have been met to a reasonable degree."

As such, enterprise education is recognised as one of the basic enablers that must be in place for entrepreneurship to grow, and to create the environment for the growth of our economies, and build the skills and capacity with the young people of today who will become the business leaders and employees of tomorrow.

[8] 2011 Overseas Development Institute report on 'Maximising impact of youth entrepreneurship support in different contexts'.

Engineering Pedagogy

Academic Readiness of Mature-Age Students

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Abstract. Academic readiness represents a certain level of behavior patterns every student needs to master in order to succeed in a credit-bearing education cycle of a postsecondary institution. To improve academic readiness of the first-year students should be one of the most important tasks for university teachers in preparatory phase of study cycle. Our survey brings the interview data on opinions of university staff and mature-age graduates from the bachelor program *Specialization in Pedagogy* suggesting some improvements on the topic.

Keywords: Mature-age students · Teachers · Practical classes · Cognitive and non-cognitive factors

1 Introduction

Academic readiness can be defined as the level of preparation a student needs to enroll and succeed in a credit-bearing education course at a postsecondary institution that offers degree [3]. The term *succeed* is defined as completing entry-level courses with a level of understanding and proficiency that makes it possible for the student to be eligible to take the next course in the sequence or the next level course in certain subject area [4]. A student with academic readiness is able to understand what is expected in a course, can cope with the content knowledge that is presented, and can take away the key intellectual lessons and dispositions the course was designed to convey and develop [4]. Academic readiness is not frequently discussed by academic researchers and practitioners at technical universities in the Czech Republic [1]. The term often remains poorly articulated, leaving university students unclear about the expectations they will face, and university staff unable to help them truly prepare. Improving academic readiness of students who enter university studies at the age of 25–35 years is one of the great imperatives. While it goes without question that mature-age distant students need strong academic skills to succeed in postsecondary education, our research indicates that the concept of *university readiness* must be more broadly conceived. Several independently conducted research and development efforts help us identify the key knowledge and skills mature-age distant students should master to take full advantage of technical university [4, 6].

In the introductory phase, a comprehensive university course should address four distinct dimensions of university readiness: cognitive strategies, content knowledge, self-management skills, and knowledge about postsecondary education [2, 3].

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2 Conceptual Framework and Current Research

Cognitive strategies and content knowledge as well as self-management skills and basic knowledge about post-secondary education known as the Big Four help students identify the key knowledge and skills [6]. Both full-time and distant students should master to take full advantage of their technical university which is not easy to study at, especially in the first phase. If the distant mature-age students are able to adapt to the technical university climate it can be considered an advantage [7, 8]. At a technical university, students must keep track of massive amounts of information and organize themselves to meet competing deadlines and priorities. They must plan their time carefully to complete these tasks. They must be able to study independently or in formal study groups. They must know when to seek help from academic support services and when to cut their losses and drop a course. These tasks require self-management, a skill that individuals must develop over time, with considerable will, practice and trial-and-error activities.

Choosing a higher education institution, submitting all necessary information, applying, taking required admission exams and then adjusting to university life all this requires a considerable amount of specialized knowledge. This knowledge also includes understanding how the culture and climate of any university is different from that of high school. Distant mature-age students generally demonstrate uneven mastery of these four dimensions which have both cognitive and non-cognitive background. Although it is important for high schools to meet the needs of all students who wish to go on to post-secondary education, even with a delay of several years, some students require a much more intentional, comprehensive program of preparation that is carefully calibrated to their needs.

To meet this challenge, educators should be more active in order to increase student academic skills. University teachers often repeat notorious fact that students must *study hard* for their class. But in high school, studying usually entails completing nightly homework, taking biweekly or monthly tests, and completing short-term assignments. Technical university *studying*, in contrast, means completing work independently, even if a teacher doesn't collect or grade it. It means reviewing a syllabus at the beginning of a course, developing a plan to complete long-term projects and studying large amounts of material for infrequent exams. As educators aim to make the academic skills needed for university readiness clearer, they should do the same thing for non-cognitive skills (e.g. some student personality traits) which is not always common practice.

3 Enhancing Academic Skills of Practical Teachers

Our qualitative pilot study confirms that academic readiness must be more broadly conceived - mature-age students need strong academic skills to succeed in postsecondary education, our experience fully meets these expectations. In our study, we interviewed 9 university staff and 22 graduates from the bachelor program for technical teachers. These interviews, conducted in summer semester 2014–2015, made clear that certain skills, behaviors and attitudes are equally germane to university success.

3.1 Qualitative Analysis of Graduate Attitudes: Methodology and Data

We used unstructured interviews, which represent a qualitative method of gathering evidence, data and information. We developed a *loose* guide, with general questions designed to open up conversation about student academic readiness. This included series of follow-up questions, prepared in advance, in order to elicit certain types of information from the informant. Qualitative research responses are not usually expressed in numerical terms, as might be the case with questionnaires.

In our survey, (22 interviewees), we identified three specific areas which were evaluated substantial for mature-age student academic success which correspond with some previous studies [4]:

- To adopt academic habits (cognitive and non-cognitive factor)
- To develop ability to balance school and other demands (non-cognitive factor)
- To engage in help-seeking (and to have teacher response, non-cognitive factor)

In their responses, most graduates believed *academic habits* can be developed if university faculty had clear expectations of their mature-age students and if they were able to precise academic habits more clearly. Mature-age student expectations differ substantively from those in high school (years ago), and while meeting them was critical to academic success, they often remained largely unspoken. The interviewees were to some extent critical about misunderstandings between them and teaching staff in this aspect: *"....many university teachers believe they already clearly articulate their expectations to students, verbally and in their handouts, but their behavioral expectations must be made far more explicit and precise…"*. Or …"*at the beginning, teachers didn't tell me exactly what to expect, so I didn't know what to do! And I felt intimidated to ask, not to play stupid…"*.Overall, the evidence points to the need for active guidance so that mature-age distant students can develop these behaviors and strategies. Graduates mean that *ability to balance school and other demands* represents another crucial aspect of university readiness: in order to optimize functioning, it is necessary to find a balance between the various potential roles a mature-age student plays: partner, father, worker, friend, classmate, etc. These roles are often in conflict, and a student must be adept at attending to a variety of factors and assessing priorities. Time management is a key component to both academic (and professional) success. It is an essential skill that will help a mature-age student concentrate all efforts on what is most important.

Help-seeking engagement was the last of the three most discussed items. In an ideal situation, students who meet the university expectation of studying hard use strategies such as breaking their syllabus into small chunks of material to learn at regularly scheduled intervals, and taking notes in the margins of their textbooks while reading. Faculty should explain these and many other successful behaviors to students on the first day of class, and regularly remind them of these and other important skills, such as recognizing when they need help, and asking for assistance rather than waiting for it to be offered. To make their expectations sufficiently explicit and actionable, university staff should first spend time reflecting also upon the non-academic behaviors and skills they expect of their students. Only once they have identified their own expectations, they can make these clear to students and develop assignments that will help students learn to employ them. For example, when a teacher asks students to *come to class prepared*, what does this mean? If this means coming to class having completed a reading and being prepared to participate in discussions about it, he/she can include this expectation in the syllabus, explain it to students from the first day of class, assign students to write out three questions or observations about the reading to discuss each week.

3.2 Qualitative Analysis of Faculty Attitudes: Methodology and Data

A similar methodology was used in the interviews with 9 teachers (ICT, teaching methodology-didactics, psychology, personal management), with a long-term teaching practice in distant studies. Interviews also included series of follow-up questions, prepared in advance, in order to encourage certain types of information:

- To adopt academic habits
- To develop ability to balance school and other demands
- To enhance work ethic

Teachers are convinced the most successful first-year students are those who come prepared to work at the level faculty members expect *(who are able to adopt academic habits)*. Those who do not arrive fully prepared – and this might be the case of some mature-age students who had completed their secondary school study 10–15 years ago, and have lost their learning skills, are significantly less likely to progress beyond entry level courses, as witnessed by the high failure rates in these courses. Instructors admit to be aware of the evidence the student-teacher relationship is much different at universities than in high schools, and again it is different in distant forms of study. But they proclaim proper tolerance in this sense. (A common example cited by some respondents was some assertive first-term freshman who is failing a course and approaches the professor near the end of the term to request an extra exam term in order to be able to pass the course, while less assertive freshmen do not dare to use similar behaviors and have to enroll the course for the second time).

Time management - *ability to balance school and other demands* was cited often in the answers, similarly to graduates answers. Faculty reported mature-age students usually enter university with a *work ethic* that prepares them for teacher expectations and course requirements, but it is difficult for them to persist during the whole study. But unlike in graduates answers, teachers were convinced their own readiness to help mature-age students overcoming early obstacles was sufficient.

4 Conclusions

Qualitative analysis of interviewees′ attitudes on academic readiness in both groups shows many similarities. But as reported by graduates, instructors should explain successful behavior models to students on the first day of class, and regularly remind them of these and other important skills, such as recognizing when they need help. Students should be more active when asking for assistance rather than waiting for it to be offered. To make their expectations sufficiently explicit and actionable, university staff should first spend time reflecting upon the (non-) academic and skills of every specific group of students (e.g. mature-age ones), and be aware of what to expect from them.

Once they have identified their own expectations, they can make these clear to students and develop assignments that will help students learn to employ the necessary behaviors. Institutions should formalize this process by asking entire departments to similarly identify and explicate the unspoken expectations to which students are held. Conversations and discussions about behavioral expectations could be conducted as part of program review, professional development or the creation of learning outcomes. Importantly, departments should then make identified academic and non-academic expectations clearer to current and future students - by embedding them into course syllabi and structuring orientation, outreach activities and success courses around them. Universities should also work with high schools and state education policymakers to ensure that academic readiness standards are incorporated into ongoing university readiness initiatives. Senior-year transition courses, university-high school partnership programs are all avenues through which expectations can be clearly communicated to students, and successful skills and behaviors can be taught.

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Who Owns the Teaching and Learning Environment?

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Abstract. This paper uses a Foucauldian Discourse Analysis (FDA) framework to examine the first-year engineering teaching and learning environment. Specifically it investigates perceptions and actions relating to the concept of ownership inside the construction of the learning and teaching space by examining interviews of lecturers and supporting related government and university policy material. In doing so this paper reveals the operation of power and its complex effects in higher education. Importantly, by doing this, it shifts the domain of investigation beyond that of the student to the context the student finds themselves in.

Keywords: Teaching and learning · First-year engineering · Foucauldian discourse analysis

1 Introduction

Like many STEM subjects, Engineering (ENG) is currently suffering from recruitment, success and retention issues, both nationally and internationally. Many researchers have attempted to investigate the issues surrounding STEM retention [1], studies which explore student experiences of the barriers to their learning and retention have enabled ENG departments to introduce changes to address some of these issues, but the problem remains.

Many of the studies which currently inform our understanding of student success and retention in STEM adopt a student perspective, and seek to address student needs as inferred from the student experience. However, the project from which this paper draws adopts a different perspective, placing lecturers at the epicenter of the situation. We argue that University, lecturers and students are all part of an educational setting which is comprised of a complex network of power relationships; and that this network is active in the operation of the teaching and learning environment.

This study adopts a Foucauldian Discourse Analysis (FDA) framework [2, 3] to investigate the ways in which lecturers in a New Zealand ENG department experience and exercise power in ways that impact the learning-teaching environment. By doing so we suggest, that the issue of STEM retention may be reframed allowing for alternative solutions to the STEM crisis. In (FDA) power is seen in the system of social networks as a process that pervades every social relationship [4]. This paper focuses on one

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question which has emerged from preliminary analysis: ‘who owns the first–year teaching-learning environment?’ We define ownership as encompassing the rights and responsibilities; the process of exercising power, by various groups and individuals over subjects in the class room. Ownership in this context is visible as processes both outside and inside the construction of the learning and teaching space, and is evidenced in one of these group’s descriptions of their experience; that of the lecturers. Due to space limitations this paper has been shortened removing many of the full text lecturer excerpts. These excerpts can be viewed in a technical paper available from: http://ecs.victoria.ac.nz/foswiki/pub/Main/TechnicalReportSeries/ECSTR16-05.pdf.

1.1 Methodology

Participants. In 2015 lecturers from Part I first year BE programme courses were invited to participate in an interview study. At least one lecturer from each course, and where possible two, participated. Fifteen first year BE students also participated on a voluntary basis, selected from Pastoral Care interviews undertaken by the first author, but are not included in this part of the study.

Data. Lecturer and student data comprise individual unstructured interviews focused on what lecturers and students thought were the barriers to student success at first year. The interviews were transcribed verbatim at the sematic level and analysed using Ian Parker’s (1992) [5] methodological guidelines. In addition, supporting documentation was gathered to contextualize participant responses. This material broadly comprised course outlines and materials from the first-year School of Engineering and Computer Science (SECS) courses, enrolment and marketing material from the institution together with SECS, Government and University information relating to tertiary strategy and policy.

Analysis. Interviews and contextual material were analysed using FDA (following Parker 1992) [5] and triangulated by a mixed disciplinary team. The primary author is a historian, the three other members comprise a linguist and academic developer, a psychologist and an electronic and computer systems engineer.

2 The Teaching and Learning Environment

Broadly speaking the teaching and learning environment refers to the context in which a university operates, as well as the classroom itself. For example, the university in this study is a publically-funded, Government owned institution operating both nationally and internationally as part of a global tertiary sector. The university environment includes the immediate situation such as the operating practices and policies that encompass the business of an educational institution, for example: funding, research, administration and teaching. This is in turn translated by disciplinary departments into day-to-day processes and policies which impact the practices of lecturers. The teaching and learning environment is perhaps most apparent in the classroom, lecture laboratory and tutorial class.

Table 1 gives a broad overview of the teaching and learning environment and an even broader look at where ownership exists for these groups, indicating the rights and responsibilities of various groups and individuals who impact the teaching-learning environment. In effect what we can see is who owns what specific aspect of that environment. There are of course many groups not mentioned that also have an effect on this, such as, tutors, administration staff and of course outside influences like family. This study focuses on the lecturers and as a result limits investigation to the table groups. Where for example, one group such as the government expects something from another group (for example, the university), we see an operation of ownership and in the actions taken in response, the operation or exercise of power.

Table 1. Ownership of the first-year tertiary teaching and learning space: rights and responsibilities

Group	Rights	Responsibilities
Business & Professional Bodies	Numbers of graduates; Graduates with certain adequate skills	Employment of graduates; feedback to Govt and university sector on quality of graduates; Accreditation and recognition of Degree
Government	Demand for Quality Education for national and International standards; Demand of quantity of graduates; Demand of accountability; Provide funding; Right to withdraw funding; Make laws that govern conditions	Funding; Negotiate with business community; Authorise, legitimize and provide educational certification
University	Interpret Government policies into institutional strategy and policy; Disburse resources according to priorities; Expect academics to meet policies; Expect Government to support through funding; Expect Government to support through policies; Expect Government to set reasonable accountability targets	Provide a teaching and learning (including research) physical space; Provide lecturers with appropriate workload (jobs); Provide opportunity for lecturers to research; Facilitate communication of processes; Meet Government accountability targets; Set policies to meet needs of all students
Lecturer	Prepared students (from High School); Adequate funding; Academic freedom; Ability to conduct research;	Teach; Produce adequate and aligned curriculum; Design appropriate assessment; Deliver quality teaching in the classroom; Deliver quality research
Student	Expectation of all parties above to construct frameworks from which they can learn; Expectation of quality teaching	Arrive academically prepared for first-year; Do the required work; Prepare themselves when here for current and subsequent study; Pay fees

2.1 Ownership of the STEM Crisis

Complex processes permeate the teaching and learning environment and reveal the operation of power. Ownership, by institutions and individuals is exerted both consciously and unconsciously as modes of control. It is important here to see that in this environment there exist multiple hierarchal tiers that operate either independently or in association with other aspects of the educational apparatus. In this sense, ownership provides an active visible process or function in the discourse, and can be seen in the statements and messages received. The political drive to have effective educational programmes in STEM and in particular in engineering, frames the context in which tertiary institutions operate. For businesses, the lack of graduates is seen as an acute problem as they rely increasingly on the growing number of STEM-educated individuals for successful economic growth in a highly competitive global economy. Unfortunately in the world of tertiary Science, Technology, Engineering and Math (STEM) education, poor retention of students is not unusual.

This desire for graduates to meet an employer need places increasing pressure on Government policy in New Zealand. In turn the Government puts in place policies for tertiary organisations to help deliver this business demand. Governments rely on business to assist in the country's economic stability and growth. In New Zealand our tertiary institution is a public university, receiving around about fifty percent of its funding from the Government. This funding is attached to what the Government Tertiary Education Commission – the body which sets university operating policy – dictates as important.

For example, one of the key goals set by the New Zealand government is the recruitment and retention of engineering students through to graduation. This is clear in the discourse as evidenced in the messages New Zealand universities receive. In 2013 the New Zealand Minister for Education announced a goal for tertiary institutions to produce 500 more engineering graduates every year from 2017 [6]. New Zealand has a population of 4.5 million people. Similar arguments have been made in countries such as, Australia [7], the United Kingdom [8], and in the United States of America [9].

The exercise of power exerted from business to Government reveals a joint ownership of this aspect of the educational environment. The implications of this 'ownership' impacts university operating policy and places it on a business footing. Every year a fresh cohort of between 150 to 180 first-year Engineering students enter our four-year Bachelor of Engineering with Honours programme (BE). They each select one of the three majors we offer, either, Electronics and Computer Systems (ECEN), Network Engineering (NWEN), or Software Engineering (SWEN). These students must attain an above-average grade across a set of specific first year courses to continue in the BE. This requirement was set to help ensure a quality of graduate and hence to satisfy the accreditation requirements of the Washington Accord.

To date the number of students who have achieved this requirement in their first or subsequent attempt has never reached 50% of the entering cohort. For lecturers, there is a clear message and a visible power directive from the government, and therefore the University, that they need to provide increasing numbers of engineering graduates. Poor recruitment and retention places universities and their academic programmes and staff under pressure to take on more students and pass them. As one lecturer puts it:

> ***Lecturer H:*** *Well okay so there's the business there's the business thing again, because the university wants - if you want to have this many staff then you've got to have butts on a lot of seats. If you want butts on a lot of seats then you're going to have students who aren't as well prepared ... on average as the ones the tiny universities could get twenty years ago or thirty years ago.*

Not only do businesses want graduates they also want quality graduates – graduates who can participate not only nationally but at an international level. There is a tension for academics who must deliver educationally sound courses at an appropriate level while meeting the demands of business and government for increased numbers of graduates. Ownership of the STEM crisis itself is multi-layered, hierarchical and made up of competing factors. The pressure to perform permeates all levels of the university and can be seen in its founding documentation. The Faculty of Engineering began offering the BE in 2007 and was the result of a strategic direction by VUW as stated in our Draft Business Case for the Establishment of a Bachelor of Engineering 2005 [10] and Business Case for Introduction of Bachelor of Engineering 2006 [11]. The draft documentation notes:

'Recent government publications (e.g. the ICT Taskforce Report, 2003 and the Digital Strategy Report, 2005) have set ambitious goals for New Zealand's ICT Sector. A trebling of jobs in the ICT sector is forecast by 2012 with an acute shortage already visible of suitably qualified graduates. This will create a significant increase in demand for tertiary ICT studies (including electronics) and a clear opportunity for Victoria' [10].

The draft report goes on to identify numerous opportunities additional funding, connections with Government and industry, the alignment of national goals and the obvious increase in enrolments as reasons to develop the BE. Interestingly, the significant threat of another institution is also stated as one of the reasons to proceed with the BE. This is an example, of the university laying claim for ownership of a disciplinary learning and teaching space.

The foundational documentation reveals what Thornton and Ocasio argue: 'while power and politics are present in all organizations, the sources of power, its meaning, and its consequences are contingent on higher-order institutional logics. Institutional logics define the rules of the game by which executive power is gained, maintained, and lost in organizations…. Moreover, institutional logics are historically variant and are shaped by economic and social structural changes' [12]. As such we can see that ownership of the teaching and learning environment does not solely belong to those teaching in the classroom (if at all). Rather, as the following examples illustrate, the lecturers' processes are affected by their interpretation of power being exerted upon them from external and intraorganisational hierarchies.

2.2 Ownership of Entry

The pressure to recruit students by the university to meet the government funding, ultimately relates back to the business pressure for qualified students. VUW has an enrolment target set by the Government through the TEC. In turn the University through a combination of recruitment and enrolment endeavour to meet this target. Individual faculties in turn have targets that they must meet in the enrolment of students. This is administered at the Faculty and then School level (such as, SECS), and individual courses also have enrolment targets that determine their financial viability. These targets are based around a business model set by university management. Lecturer D described the effect of the business model of recruitment, noting that pressure from university senior management resulted in processes where our faculty and Dean where put in a position where they had to admit less academically desirable students.

A consequence of this is that a significant amount of our first-year cohort cannot take all the papers required in their first year and need to take bridging papers. Students who VUW has let in believe the courses are going to be of an achievable academic level. Lecturer A describes the justification supporting this process:

> ***Int:*** *So why do we let a whole lot of people in to the BE that we think are not academically prepared*
> ***Lecturer A:*** *Multiple reasons, one is money... Another is giving people an opportunity... because we don't know... Whether they're going to fail, and giving them an opportunity to try- I think that's important.*

This policy allows students to enrol who could fail because they do not have the required academic background to enter the course. Equal opportunity for entry does not mean equal opportunity for success. Success in this sense would be in-part determined by the quality of the instruction and having appropriately designed material to allow those with poor academic background a high chance of passing and gaining the knowledge to succeed in subsequent courses. Ownership of entry by the university places considerable demands on both students and lecturers to be successful, and makes the role of the lecturer pivotal in the classroom teaching and learning environment.

2.3 Ownership of Courses

In the tertiary education environment, lecturers exercise the freedom to design and deliver their courses with little direct input from other lecturing staff, the university or government. This relative lack of input in part relates to the constructed identity of academic freedom/ownership as generated by the role of lecturers within a broader tertiary educational environment.

This freedom places ownership of the university course in the hands of the lecturer. The following two passages, reflect how the concept of academic freedom is expressed as ownership through the freedom of choice:

> ***Int:*** *How much is that academic freedom and the nature of the way we structure things here, how much of that's the barrier to first-year students?*
> ***Lecturer A:*** *I don't think it's a barrier - I don't think that's the barrier. I think that's the reason barriers won't get torn down easily... The different views and attitudes of staff and in some case straight poor teaching methods or attitudes, that's not the barrier, students don't have to interact with that at all. What they interact with is the lectures and the assignments and the exams and the assessment and the labs the things the course design.*
> ***Int:*** *Yes, but ... does that not come out of those other things?*
> *Lecturer A: Yes it does... But those things are the barriers... And how you change - how you reduce those barriers? I do not want to even think about taking a head-on attack on those issues of academic freedom and... teaching things.*

Lecturer A draws attention to the nature of academic freedom as a barrier to students and a barrier to change. Ownership of the way a lecturer designs or teaches a course reveals the power relationship at work in the organization. Diffusing ownership of courses to individuals makes the task of coordination and educational reform difficult. Lecturer F below exposes the inherent sense of individual ownership lecturers have through emphasizing that freedom of diversity is preferable to an agreed course design approach:

> ***Int:*** *Well, essentially what you're saying there is your academic freedom, you would like to retain in terms of what you teach. How does that sort of freedom impact on the students or the way we organise our courses?*
> ***Lecturer F****: I don't know. I really don't have a strong opinion, I mean I feel that so like, you know, if I had my way I'd work the students quite a lot harder… maybe I should just do that anyway. But I don't know so I would rather that there is, sort of diversity amongst lecturers, than an agreement that this is the right way to do it.*

We can see the mandate for this level of academic freedom in Government policy. Our organization, adheres to the provision of academic freedom as expressed in the New Zealand Government Education Act 1989: 161 [13]. This act notes, among other things that the institution and its staff have freedom to regulate the subject matter of courses taught at the institution and the freedom to teach and assess students in the manner they consider best promotes learning. However, academic freedom is not unconstrained freedom, as the Act goes on to note that educational institutions must be publically accountable and maintain the highest standards. The Government assumes that the lecturing staff and the university as a whole have in place appropriate educational mechanisms to facilitate student success for the majority of entrants. It also assumes that the mechanisms of accountability established through the TEC and the university body are sound.

Interestingly, there is a tension between freedom and accountability. Accountability of an educational institution raises the question of whether there is true freedom. Accountability embedded in the Act works to constrain this freedom in certain ways. For example, one mechanism that is applied to enforce accountability is the low-performing provision or (LPP). The New Zealand Government which has overall ownership of the tertiary strategy and funding policy, sets requirements on the number of students it expects to pass individual courses (not a programme of courses) in order for the course to maintain full funding.

The TEC requirements under the low-performing provision (LPP) allow for removing funding for courses that fail to pass more than 60% of those enrolled, if a course falls below this threshold for two previous years. The TEC does not arbitrarily withdraw funding but looks at each course on a case by case basis. Included in this assessment is consideration for the reasons relating to poor performance [14].

Currently VUW has never received a formal request for funding to be returned. However, the TEC has the ability to do this and can in the future 'claw back' funding for courses that have breached the conditions/rules since inception of this policy into law. If funding were clawed back it would be the full funding for the course concerned and not only for those students that did not pass. Lecturers noted that scaling was a common practice used to meet the targets. One lecturer, while reluctant to admit scaling occurs certainly indicates an awareness of the need to take into account pass rates:

Lecturer J: *I realise that the pass rates are a cause for concern… both, you know well basically that quality of students entering second year is a cause for concern. I mean a couple of years ago it was it was a great cause for concern about the actual pass rate because we were getting close to that trigger point Where you know fees can be pulled back…*
Int: *Yeah, so, well that's an interesting point so I mean do you scale?*
Lecturer J: *I never had to thank God… So ((laughs)) I'd - really don't want to, but there was one year when we quite close and we looked very hard at it, and we reached some kind of accommodation where we don't feel we're being unfair to anyone.*

From the perspective of the first author as a staff member in SECS, there is a common verbal acknowledgement by staff that they have to ensure that course pass rates do not drop below the TEC claw back level. This has on numerous occasions been conveyed to staff in meetings with senior management, and may be in focus, as Lecturer J describes during meetings about scaling student grades. This process puts an interesting aspect on ownership, the lecturer may own the classroom and assessment, but not the percentage of students deemed to 'pass'.

In terms of power this is what Foucault would term as being not obvious or invisible power – in this case it is the institutional processes and cultural context of VUW and SEC relating to their interpretation of TEC messages. This interpretation, while lacking a formal overt structure still acts, albeit in a decentralised way, throughout the hierarchy of the university and the ways in which individuals within these environments interpret the messages they both receive and in turn act to create and perpetrate for others.

Academic freedom does not suggest that there are no controls or constraints on course design but rather that what controls exist are minimal with the lecturer considered the subject and teaching expert. VUW has a Programme and Course Design Handbook, however it is difficult to tell if this has any significant direct effect upon individuals' course or programme design [15]. The course design book is a necessary administrative document that shows outwardly that this aspect of the teaching and learning environment is taken seriously but it does not significantly challenge ownership of courses by lecturers and pass rates by university management and the Government.

Controls on course design within SECS are handled by the various majors teaching groups and by course auditors. A course auditor is assigned to every course and takes the form of another academic who is supposed to review the course and complete a checklist before signing off the course. According to interviewed lecturers, in reality little is done and in many cases the lecturer would not do an in-depth investigation of a course they sign off. The respective teaching groups talk about content of courses but do not generally get involved in how a lecturer teaches or assesses a subject.

All this reinforces that there is considerable freedom of operation of lecturers and courses which results in relatively ad-hoc communication between lecturers and reasonably informal course- and first-year programme design process. Lecturer E aptly describes one current method of course design:

Lecturer E: *From my understanding of how the courses are constructed, the courses are constructed by setting a set of learning objectives which are assumed to be met from the previous courses on a whiteboard… And then they say if they know this then we can teach them this and this and this*

Int: *So if we don't know what...they're coming in from school with... In terms of background knowledge how are we making that? Are we just making an assumption of what they should they should know?*
Lecturer E: *Yep*
Int: *Based upon what... So is that based upon just gut intuition of the lecturer?*
Lecturer E: *It seems to be...*

Lecturers' A, C and F also illustrated a similar disorganized approach to course design and planning. Lecturer F indicated a lack of guidance from his colleagues and reveals an interesting process; one that indicates that lecturers are reluctant to tell others how to teach and do not appear to be sure of who owns a particular course. The lecturers interviews all point to the effect of academic freedom and the lack of clear deliberate educational management, the result of this is the promotion of a culture of individualism. This individualism places ownership of specific course subjects, materials and practices within that of the individual lecturer.

Individualism and a lack of communication can be seen in the following excerpt, however there is also a desire for greater communication and shared course design:

Lecturer D: *I think the courses could be improved. One of the ways the courses could be improved is by the lecturers starting to talk more together. Whether they should have done this in the past is a moot point because it wasn't done and now it ought to be done... A more cohesive approach between the courses is good. I would like to think we would get to a cohort approach but I don't think we will...*

Lecturer D talks about a "cohort approach" – so that curriculum could become joint ownership of course material across courses but also notes in the full interview of the difficulty of changing the individual nature of the course design due to the requirements of prerequisites and corequisites. Lecturer A below points to an alternative view for the individualism and lack of cooperation when he explains that lecturers are perhaps more interested in BE courses which are closer to their research interests. The lecturer also shows how this individualism of ownership through academic freedom makes it difficult for lecturers of differing opinions to work cohesively. Lecturer A noted in the interview that though he can 'mentor' and the other lecturers can use his course material, he still cannot own the teaching-learning environment of another lecturer's course. When a lecturer takes over the teaching in a course it becomes the 'property' of that lecturer. Evidence of this can be seen below:

Int: *Do you guys talk about what's going on in your courses?*
Lecturer A: *There's some discussion, not a lot.... I don't think they're especially interested in [course planning]...*
Int: *Is this true across the programme, I mean is it an academic thing?*
Lecturer A: *When you get to the higher level - When you go to the third year you get much more ownership of material.... It tends to be in the specialist area. So Lecturer S is the database person that's her course she cares about it... Lecturer T has half of the AI course and Lecturer U has the other half and they disagree quite considerably on what ought to be in there. And neither of them are happy with each other. And they talk but they don't say what they actually think 'cause then they'd start fighting.*

The excerpts above illustrate how the concept of ownership has an impact on the way our courses have been designed and delivered. They also show how individual ownership of the teaching and learning space is part of a complex system that points to varying aspects of individual ownership and also points to a certain lack of ownership. Lecturer A's admission that lecturers difference of opinions can lead to fragmentation within courses with lecturers apply discrete ownership of their sections and in effect apply a complete lack of ownership for the other parts of the course. In the description below we see that this lack of ownership or responsibility can translates to a complete lack of direction in a critical first-year course:

> ***Int:*** *What's the purpose of EngineeringA which is this compulsory core course all engineers take?*
> ***Lecturer G:*** *You know it's kind of like we are making it up as we go along ((general laughter))... We come up with what we call a plan, a schedule, okay? But there's no clear vision, you know on what it is actually intended to achieve you know. It's only later when you talk to some more experienced ones that they [say] 'oh so you were supposed to do that'*
> ***Int:*** *Okay, so this is what more senior academics in the department?*
> ***Lecturer G:*** *Yeah yeah*
> ***Int:*** *So they have an opinion on what the course should do?*
> ***Lecturer G:*** *Yeah yeah*
> ***Int:*** *So had they not made that clear to you guys?*
> ***Lecturer G:*** *No.*

The net effect of the lack of coordination and communication between lecturers and courses is that there has been no clear design and delivery of an integrated first year curriculum. There is a lack of communication of course content, best-practice or the use of pedagogical theory in the first year courses which marks a clear shift from the government, business and university goals of delivering both quality and quantity of students. Academic freedom has in effect resulted in the relinquishment of the means to effect a comparative and measureable quality education. This fact was illustrated by Lecturer A when he noted above that he could mentor but not change a course. There is no official way for a lecturer or for that matter an Associate Dean Academic to force course change, in design or teaching methods, unless a course received extremely bad student feedback. Ownership remains a contested space in the teaching and learning environment.

2.4 Ownership of the Teaching

There is also little evidence in the interviews of acknowledgement of a student scaffolded learning process. This is not surprising when one understands that there is a systemic lack of adult educational training in the university sector. Academic freedom given to the tertiary sector in New Zealand maintains no official requirement that academic staff obtain and maintain a teacher training qualification despite other required accountability measures. The message from the Institution, as perceived by academic staff is that, in a research-intensive and competitive environment, teaching is not an important enough skill to justify training. Experience at university in an academic position is considered on the job training.

We can see this lack of emphasis on teaching skills as an invisible power structure at work imparting this message by virtue of not promoting a culture where educational pedagogical knowledge is considered paramount. Evidence of this power exerted upon them can be seen in the fact that 13 out of the 14 lecturers interviewed do not have teacher training qualifications. These lecturers rely on hands-on learned experience, informal conversations with other staff and the occasional attendance to a Center for Academic Development course or seminar.

Course design and teaching is perceived as secondary for many lecturers due to the messages they perceive from the university and government concerning their research duties. Lecturers are subject to the power of the institutional and government discourse and react according to their understanding and experience of it. The lecturer's universally described in their interviews that they were employed as researchers and this was how they were measured in their job performance. Several lecturers were clear that their promotion relied on research outputs not teaching. Lecturer G identified the major competitive relationship academics have between the desire to deliver research versus the commitment expected in teaching and course design. The question of who owns the learning and teaching space exposes that fact that there are multiple stakeholders-multiple pulls and pushes on all of those involved. It also raises the issue, as Lecturer G pointed out in his interview, that inaction or resistance in the teaching space has an effect of not promoting the importance of teaching skills.

2.5 Ownership of Learning

While, the previous sections have explored the broad framework of ownership in the classroom, there remains a further process – ownership of learning. Ownership of the learning belongs both to the student and the lecturer. The lecturer is responsible for the delivery of knowledge through education. Knowledge itself, is intrinsically linked to acceptance or conformity with the rules and meanings espoused. A key theme of this discourse lies at the heart the educational nexus and is rooted in an Enlightenment conception of modernity. Richard Edwards and Robin Usher identify this in their 1994 book Postmodernism and Education where they note: 'Education is very much the dutiful child of the Enlightenment and, as such, tends to uncritically accept a set of assumptions deriving from Enlightenment thought. Indeed, it is possible to see education as the vehicle by which the Enlightenment ideals of critical reason, humanistic and individual freedom and benevolent progress are substantiated and realised' [16].

This statement locates the power struggle of educational discourse in the theoretical battle for ownership of 'truth'. Edwards and Usher cite Jean-François Lyotard (1924–1998), the famous postmodernist philosopher who argues: 'that the project of modernity is deeply intertwined with education, modernity's belief being that progress in all areas will emancipate 'the whole of humanity from ignorance, poverty, backwardness, despotism…thanks to education in particular, it will also produce enlightened citizens, masters of their own destiny' [18]. In doing so they claim that education's primary rationale is founded in the humanist idea of a certain kind of subject. The humanistic idea of a subject in this educational sense describes a person who as an inherent potential to be self- motivated and self-directed. Educations' role is to take this subject and help them fulfill this [16]. However, the fulfillment of this takes place through the particular lens of an educational institutions teaching practices – in the broadest sense.

We can see this creation of a subject in the way lecturers describe students or the way students perform in their classes. For both the student and the lecturer; the lecturer becomes the owner of the teaching space and the director of the learning environment. The interviews illustrate that lecturer ownership of the learning environment creates a contested space for students, where ownership of the actual learning only belongs to a certain type of student, with a certain ability:

Lecturer E described the learning space as being set up for the top students, the ones who are self-motivating, self-learning, responsible and academically excellent. The lecturer also notes that most of the students we have do not fit this category. As such, we the learning space is designed for a certain category of student. This conflicts with the rights and responsibilities in Table 1 by limiting the potential success in the learning space to a certain group of students. This lecturer also draws attention to the fact that the entrance requirements send a message to the student that they have what is required to succeed which seems to be at odds with the idea of only teaching the top students.

> ***Lecturer C:*** *Because the academic stand point is looking at the top cohort, under some measure of the high school students so, apart from that top cohort everybody else struggles.*
> ***Int:*** *So we pitch our courses at the top cohort?*
> ***Lecturer C:*** *I think so… Well, of the top high school cohort which is not necessarily the wrong thing. The University doesn't want every high school graduate I think… but it's very easy then to fall in to aiming at the top ten percent of the class here, which is the top, might be one percent from high school, and then there's - there's big transitional issues in the learning styles - how to organise stuff, being organised.*

Like Lecturer C, several lecturers identified in their interviews that the learning space is aimed at teaching students who fit the category of being self-motivated, self-directed and have a high level of academic ability. However, Lecturer K also identifies differing opinions amongst his colleagues about the role of education, and also has the perception that higher education should benefit all, not just a certain group. It is certainly the duty of students to be academically prepared for higher education and a right of lecturers to expect this, though as discussed earlier exactly what level of preparation required is complicated by varying messages. Students arrive in courses with university entrance granted according to their high school academic level, yet this level is not necessarily the same as what is required by lecturers in their courses.

In addition, having a learning environment that targets a certain type of student allows the lecturers freedom from the responsibility of ownership for the learning of students who don't fit their view of what is good academic preparation. It is clear that ownership over the level of academic preparation represents a tension between the messages the university are sending academics through enrolment policies and their academic freedom to set an educational level. Failure to possess the required level of academic ability, motivation and independent learning positions these students as subjects who are unsuitable for the current system. We have an environment where the enlightenment ideals of teaching and making a certain subject are in-built within the educational system and represents a 'truth' within the discourse. Not truth in the sense that it is actually true, but true for the particular operation of power in this situation. There is consistent but possibly unconscious acknowledgement by lecturers that successful students – the subject – in the educational context has inherent qualities that remove ownership of the need to develop extensive teaching skills or teaching materials that would help an ‘other’ type of student.

This is visible in the academic discourse above and is at odds with the business goals of the government and university. As such, it can be seen as resistance to the demands for better education and ownership of the teaching and learning space by Government and institution, but is also acceptance of ownership of a discourse which divides students into good or bad.

3 Summary

Government, business and university policy, coupled with lecturer perceptions, subsequent actions and inactions reveal the operation of power networks in the New Zealand teaching and learning environment. For example, Government and businesses are looking for engineering graduates. Government funding is conditional on a mixture or recruitment, course completion and graduation numbers, with the additional demand for research encroaching on these. VUW is looking to meet enrolment and graduation targets and to deliver the required number of graduates while maintaining a highly ranked international university. Within VUW, Faculties and Schools seek to meet their course completion targets, and graduation targets, while maintaining quality of student outcomes, and research accountability. Subsequently, lecturers are looking to maintain their standards for educational quality, teach courses and conduct research while also contributing to administration duties.

While Government and business exert ownership over the university, it in turn applies it over lecturers who react with counter-ownership. This exercise of power is a continuous series of actions and reactions, compliance and resistance. For example, lecturer inability to set restrictive entry standards leads to the reluctance of lecturers to amend the academic level of their courses. The result is a reluctance to fully comply with the business and Government need for increased numbers of passing students. The lecturers indicate that the teaching of courses is aimed at the ‘top’ student, thus individual course targets have to be met with scaling for poor performing students.

There is a growing gap between the responsibility and rights of all the groups in listed in Table 1. The lecturers have ownership over the right to construct curriculum, but do not have to talk or cooperate with each other or fully interact with business or professional bodies. The lack of communication and integration results in an individualistic first year teaching culture and course design. The acquisition of teaching skills is not emphasized in the operational procedures of the university. There is a growing realization that we need to operate differently to meet the needs of the students. As can be seen in the lecturer interviews, some lecturers want to share their teaching and curriculum development, while others do not.

There is a constant message in the interviews of increasing and competing pressures on academic positions. Lecturers describe a lack of time to meet the pressures placed upon academics. Ownership of the course and classroom teaching is given to academics, but not in a way where they feel empowered to improve content, context or process. This problem is exacerbated by the competing demands of research, publishing, administration, as well as the agenda of recruitment and retention.

The concept of ownership in the teaching and learning space represents a manifestation of power, and also of resistance to power. The consequence of competing ownership on the teaching and learning space suggests that there are negative effects for students. Further work will investigate the tension of competing demands on lecturer time, expressed in the need to research and contribute to the Government and New Zealand University Performance Based Research Fund [17].

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Application of the "Fishbone" Technology in the Organization of Independent Work of Students in Higher Mathematics

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Abstract. Formation of a creative personality able to self-development, self-education, and innovative activity is the main objective of graduate education. In this regard, a special attention should be paid to the organization of independent work of students in a university educational process management. One of the most recognized types of independent work of students is a functional conspectus. "Fishbone" technology (a type of functional conspectus) is a method of cause-effect relationships structural analysis, which allows developing students' skills to work with information and their ability to formulate and to solve the problems. This paper deals with the application of this technology to the practical work on higher mathematics in order to increase the efficiency of the organization of independent work of students. Thus we have two objectives: first, to test the effectiveness of "Fishbone" technology in the organization of independent work, and second, to explore the possibility of using this technology in the higher mathematics university course. Comparative analysis of the test results of students who were trained with "Fishbone" technology application and without it demonstrates that its use can significantly increase the level of new information assimilation (in 19.8438%). Therefore, in future work we plan to consider applying other types of functional conspectus, such as insert, text markings, clusters, conceptual table and Bloom's chamomile to the course of higher mathematics in order to compare their efficiency in the organization of independent work of students and identify the most productive of them.

Keywords: Independent work of students · Functional conspectus · "Fishbone" technology

1 Introduction

At present time one's knowledge depreciates very quickly (about 15–20% per year). In other words, after 3–5 years a graduate loses much of the knowledge gained during the years of study. Under conditions of scientific and technical progress once acquired knowledge quickly becomes obsolete. Thus, the ability to acquire knowledge independently takes on great importance. Hence, the emphasis in education should be placed on the development of self-learning skill, development of the skill of creative

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application of acquired knowledge, as well as to the adaptation to the professional activity in the modern world. Prominent authors note that the independent work of students "forms a readiness to self-education, creates a database of continuous education" under rapid updating knowledge condition [1–5].

Functional conspectus is one of the most important forms of independent work of students [6]. There are several varieties of functional conspectus. They are "Fishbone" technology, text marking, insert or efficient reading technology [7], clusters or bunches [8], conceptual table, and question chamomile or Bloom's chamomile [9]. Among all the varieties of functional conspectus we chose the "Fishbone" technology because it is the most promising for use in the higher mathematics studies. It allows students to divide the overall problem into a number of reasons and arguments. It also teaches to substantiate the assumptions, to visualize the relationship between cause and result, and to rank the factors according to their importance.

The term "Fishbone" [10, 11] means "fish bone". The scheme was invented by Japanese Professor Kauro Ishikawa for the structural analysis of causality. The problem at hand is placed in the head of the fish skeleton (see. Fig. 1, left). The skeleton has the upper and lower bones. On the upper bones students fix the cause of the events. On the lower bones students write the facts, confirming the choice of causes. Notes on the bones should be brief. It should be the keywords, phrases, facts that reflect the crux of the matter. The conclusion on the problem should be placed in a tail part of the fish. Due to the fact that students may encounter difficulties in the preliminary finding of the causes and in the determining of the rate of its influence, the most effective way to use "Fishbone" scheme is use in the classroom, which are summarizes and systematizes the gained knowledge.

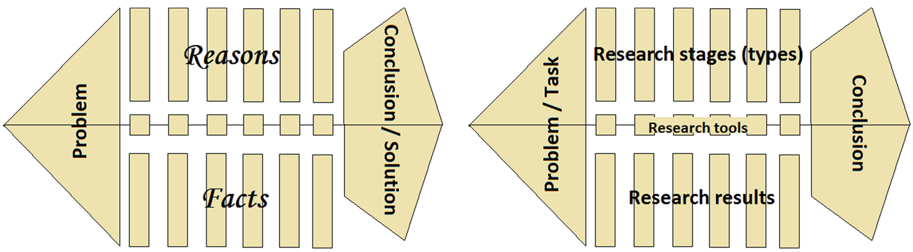

Fig. 1. "Fishbone" scheme (left); "Fishbone" scheme adaptation to mathematics (right)

The goal of our work is the "Fishbone" technology application in higher mathematics practice in order to improve the organization of independent work of students. Research objectives are:

- To test the effectiveness of "Fishbone" technology in the organization of independent work of students;
- To explore the possibility of using this technology in the study of higher mathematics course.

We compare the test results of students who were trained with "Fishbone" technology application and without it to examine the effectiveness of the approach.

2 "Fishbone" Technology Application in Mathematics

In mathematics "Fishbone" technology is convenient to use as a visual scheme of solutions of volumetric problems with exploratory nature. Research stages (types) are located in the upper bones of the fish. The spine consists of bones, where the mathematical tools of the study are located. The lower bones include research results (see Fig. 1, right).

Adapted to mathematical problems "Fishbone" scheme was successfully put into practice in the study of one of the most complex topics of higher mathematics "Indefinite integral" for the first year students of the Institute of Cybernetics and Institute of High Technologies of Tomsk Polytechnic University. It is well known from the experience of previous years, that the greatest difficulty for the students in solving problems of this topic was the choice of integration method. Many students recognized this fact, and found the solution easily after integration method was suggested to them. Therefore, the aim of the following treatment was integration method skill acquisition.

After all integration methods had been studied at the practical training, students were asked to complete a functional conspectus of four fish skeletons. In the heads of the skeletons the following problems were identified: "Integration by parts or a summarizing under the sign of the differential?", "Integration of trigonometric functions", "Integration of irrational functions" and "Different methods of integration." The upper bones of the skeletons "Research stages" included the indefinite integrals. On the lower bones of the skeleton "Research results" students have to write down the method of integration by which it was possible to find an appropriate replacement or specify substitution equation (in the case of irrational functions). On the bone of the spine they should substantiate their choice. The tail of the fish should contain a general conclusion for the integration.

Then the students received their test results and all four correctly completed functional schemes for self-error analysis. Students were also made aware of the fact that in a week they will re-do the test on indefinite integrals. Wherein, the best score will be taken into account. Consequently, they were interested in a thorough analysis of their own mistakes. The second test included different problems of the same difficulty level. Table 1 shows the results of both tests and functional conspectus. In the first column the student's serial number is indicated. The second column contains the score of the first test, and the fourth contains the score of the second test. The result of functional conspectus is shown in the third column. The fifth and the sixth columns include the results of the first and second tests of the group, where the "Fishbone" technology was not implemented. The maximum score is 8 points. Some students have received more than 8 points due to additional tasks completion.

Table 1. Tests results on “Indefinite integral” topic.

	With “Fishbone”			Without “Fishbone”	
Student’s serial number	Test 1	Functional conspectus	Test 2	Test 1	Test 2
1	0	2.62	5.4	6	6.3
2	2	2.33	4.1	2	4
3	4	4.07	4.3	3	2.6
4	4	6.7	5.3	5.5	6.2
5	1	3.49	3.8	0.5	1.8
6	0.5	2.04	0.5	0	1.5
7	3	5.24	3.5	7	8
8	2	4.51	4.6	3	3.5
9	0.5	2.76	2.7	5	7
10	5	3.35	3.8	5.2	5
11	1.5	2.33	0	4	3.8
12	3.5	6.11	6.2	0	1
13	0	1.31	0	2	1.5
14	3	6.25	7.3	2	3
15	8	6.4	9.8	1	3
16	1.5	3.64	2.2	0	3
17	1.5	5.38	3.2	2	2.2
18	2.5	2.76	3.6	3.8	4.1
19	4.5	4.95	4.9	5	5.5
20	0	4.51	1.6	1	2.3
21	0	2.91	0	0	0.3
22	5.5	5.38	7	0.5	0.7
23	0	1.6	0	2	1.6
24	1	5.38	2	2	2.4
25	7	6.11	7	0.5	1
26	0	1.6	6.3	4	4.3
27	0	2.18	5.8	5	4.9
28	6	4.65	7	0.2	1.4
29	0	3.78	2.8	4	3.5
30	0	0.44	0	5	5.9
31	8	5.38	9.4	0	0.3
32	3	4.36	3.7	4	3
33	5	3.05	6.8	0	1
34	4	4.65	4.3	3.8	3.6
35	7.1	4.65	6	7	6.8
36	4	3.93	4.5	7.2	7.3
37	1,5	4.51	5.2	5.2	5.4
38	0	3.05	2	3.8	3.7
39	0.7	1.16	4.8	0.9	2.8
40	1.9	3.51	4.8	0.6	2.9

Table 2. Statistical characteristic of the tests’ results

Statistical characteristics	With “Fishbone”			Without “Fishbone”	
	Test 1	Func. consp.	Test 2	Test 1	Test 2
xb	2.5675	3.82575	4.155	3.293	3.813
D	5.833	2.484	6.163	5.235	4.124
σ	2.415	1.576	2.483	2.288	2.031

Table 3. Sample correlation coefficients of the tests’ results

	With “Fishbone”			Without “Fishbone”	
	Test 1	Func. consp.	Test 2	Test 1	Test 2
Test 1	1	0.646	0.73	1	0.938
Func. consp.	0.646	1	0.571	–	–
Test 2	0.73	0.571	1	0.938	1

3 Data Analysis

Processing of the results of “Fishbone” technology application to practical training in higher mathematics was carried out using statistical methods [12]. Tables 2 and 3 summarize the main statistical characteristics of the test results. Here *xb* is the sample mean, which is equal to the sum of all points for the test divided by the number of students. The sample mean represents the average result of the test. *D* is the sample variance. It is equal to the sum of the squares of deviations of the students’ scores from the sample mean, divided by the number of students. This value characterizes the dispersion of the individual scores of students with respect to the sample mean. σ is the sample standard deviation, which is equal to the square root of the sample variance. It is used to find the correlation coefficient. Sample correlation coefficient characterizes the presence of a linear relationship between the variables. If the sample correlation coefficient is equal to 1, the variables are linearly dependent. If it is equal to 0 there is no linear relationship between the variables, but there may be some other relationship. Ones on the diagonal in Table 3 mean that there is a linear relation between the same variables. The value of 0.73 indicates that the relationship is not linear between the scores of the first test and the second test. Value 0.938 proves a linear relationship between the control points for the first test and the second test. Thus, second test results of the students who used the “Fishbone” technology do not depend linearly on the results of the first test, while for the second group (without “Fishbone” technology implementation) this dependence is linear.

4 Conclusion

One of the main tasks of modern education is to create sustainable students motivation to learn. Another task is to search for new forms and tools of knowledge development through creative solutions.

This work describes one of the most important types of independent work of students. “Fishbone” technology allows to set the goals of learning, and to establish the ways of achieving these goals. The application of this technology in a higher mathematics practice was considered. On the basis of statistics it was found that the use of this technology can significantly increase the level of new information assimilation (in 19.8438%). Therefore, in future work we plan to consider applying other types of functional conspectus, such as insert, text markings, clusters, conceptual table and Bloom’s chamomile to the course of higher mathematics in order to compare their efficiency in the organization of independent work of students and identify the most productive of them.

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The Importance of Writing in Software Engineering Education

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Abstract. In this paper we present our first steps in defining the type, scope and relevance of writing in higher education of software engineering. We aim to identify lacks of scientific research and raise a new and necessary research interest to push research in this area. First we clarify the relevance of writing in higher education in general. In a second step we highlight the relevance of writing in the domain of software engineering in particular. Soft skills to be taught to students of engineering professions and especially to software engineering students are highly discussed. We discuss the skill of writing from a theoretical view as well as reasons for the high relevance of this skill for future engineers. An obligation of teaching writing in the higher education is formulated.

1 Introduction

EVELIN[1] is an interdisciplinary project that contributes on establishing an own software engineering didactic and focusses especially on required technical and non-technical competencies in this domain. Hence, special attention is payed on the improvement of soft skills of software engineers in the context of higher education. Didactical principles are combined with technical issues and necessities. Our approach is based on writing in a two dimensional view and its importance in higher software engineering education. The pedagogical view focusses on writing concerning the type of professional writing in general and writing as a general task of higher education. The domain- specific view presents the fields of activities a software engineer needs writing skills. Both views are mutually supportive. The transfer of our insights to higher software engineering education shows the general need of practising writing in software engineering education at universities, apart from coding in a specific programming language and the often focused type of scientific writing. In our work we concentrate on writing tasks in natural language in each phase of the v-model that except programming.

2 Writing in General

After a decade of spoken language aiming at the "communication skill", writing in German didactics is newly discovered in the eighties [1]. Writing uncovers

[1] www.evelinprojekt.de.

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thinking and serves not only as knowledge acquisition but also as knowledge control in its original function of communication [2]. Central aspects concerning writing can be described as follows:

- The modelling of the performance of writing as complex (problem-solving) processes.
- The comprehension of development processes to explain the development of the writing skill.
- A process-oriented writing-didactic and the resulting consequences for supporting writing [1].

It is getting clear: writing can be seen as a dual role. On the one hand, writing can be used as a tool to reach further skills; on the other hand, writing itself as a learning skill can be the focus. Various methods of writing applied in specific didactical settings support the process of writing in its function. The active process of supporting writing skills starts a school in its latest point.

3 Writing Concerning Higher Education

Acquired writing capability is not only achievable by school education [1]. Writing skills and abilities acquired in school refer to a specific level. This level should be the basis for further qualification steps [3]. Therefore, literal praxis taught in school has to be practised continuously in extracurricular context, for example in the context of higher education. Therewith a successful literal socialization with regard to a working context at a later time is enabled [1]. Linguistic actions always happen in specific areas or domains in our society. A society is always characterized by values and norms giving a frame we are operating in [4]. Hence, universities have the general task to educate writing skills continuously and systematically, if students should be prepared for future field of work [5,6]. Further, it can be stated that drawing up texts happens under dedicated conditions. Depending on the domain its interests and requirements, specific norms and conventions have to be observed [7]. Therefore, universities of applied sciences have the specific task to focus on domain- and cultural specific writing besides the general task to teach scientific writing [7]. Pogner emphasizes the domain- specific reference that the process of writing is considered as an action motivated by professional aspects and that serves professional purposes [8]. A domain- oriented higher education has to observe the particular required types of texts and spectre.

4 Domain-Specific Writing

The research field of domain- specific writing deals with sectors and occupational field for whom or in whom is written. The associated institutions and discourse communities reach agreements about the way of professional interaction and embedded opportunities for communication and communication processes; e.g.

which contents must be communicated to whom in what way? [4]. The scope of subsequent professional initiated writing processes is broad and heterogeneous [5]. Surveys illustrate, in almost every profession a lot is written; practitioners have to handle a wide range of text production tasks as well as they have to adjust rapidly to changing context conditions [3]. Hence, text production in general and writing processes at the workplace in particular always happen under specific conditions, influenced by various factors [4]. Jakobs suggests a model, which combines psychological, linguistic, text linguistic and sociological approaches of general conditions of text production actions. She proposes to specify following contextual conditions according to the domain: "writer", "workplace", "institution", "domain" and "cultural region" [4].

5 The Domain Software Engineering

As already stated in Sect. 3, writing is an important aspect in almost each profession; this is also true for the domain of software engineering. In this section the contextual condition "domain" is described, to visualize domain- specific cultural, social and economic norms for the writing interaction with competitors, partners and customers.

5.1 Writing in the Domain of Software Engineering

Lehnen outlines in 2005 [9] a scientific lack in knowing domain- specific types of texts. Furthermore, domain- specific writing skills and their didactic mediation has to be investigated. The text producer has to know the conditions and values to act appropriately in his text production. Writing in profession is always part of situational acting [4]. Our research of devotes to texts, produced in German-speaking areas because we assume the influences of culture- and national specific circumstances differ for the factor domain [4].

The discipline of software engineering takes care of the process-driven development of software. Therefore, it is important to be aware about the fact, like in other engineering domains too, that the final product is only the result of a completed engineering process. Thus, the focus in software engineering is not only the resulting product (here software) but also to traverse the full development process and therefore to guarantee quality of the product. An often underestimated fact is the importance of documentation. For example, a bad documentation, incomprehensible and unclear, often causes high costs in the maintenance of software [10,11]. Exemplary, in [10] the authors present a review of categorized problems documentation suffers: non existent, poor quality, outdated, over abundant and without a definite objective, difficult to access, lack of interest from the programmers and difficult to standardize. Since this internal documentation is almost always created by software engineers, the topic of technical writing, our special case of domain- specific writing, is of high significance [11]. Next to be able to document in a clear and transparent way, software engineers benefit from having writing skills in other important working tasks.

Creating presentations for customer meetings, writing e-mails or memos are just a few types of media where a software engineer needs writing skills in his field of work.

As main difference between general writing or writing a newspaper article and technical writing we consider effective comprehensibility that has to be achieved by a technical text. That means: "Does the reader effectively get the message I want to send out?" Before giving attention to the "how" of teaching writing skills with the aim of an "effective comprehensibility", it is necessary to identify the concrete activities where a software engineer has to write [11].

5.2 Identification the Writing Areas in a Software Development Process

To identify the concrete activities where a software engineer needs writing skills, we took a common software development process. Good software always should be developed using a software development process model. Artefacts are different for each development process and often adapted for each project, additionally.

In Schmidt [12] an approach of teaching writing in software engineering courses is given by using the Rational Unified Process (RUP) [13]. As it is our intention, the authors also combined professional writing education with a software engineering module. Learning outcomes were extended by learning outcomes for technical writing.

As already indicated with "effective comprehensibility", it is stated that the domain- specific production of texts is no subordinate work such as "writing down". Such texts have to provide clear activities for concrete persons. Following this, a writer has to be precise, explicit and concrete regarding the addressee [11, 12]. Prechelt, as well as Schmidt [11,12] give instructions how to deal with this in technical documents [11,12]. The v-model is a document driven process model and exists in two variants: the v-model 97 and the v-model XT. Furthermore, both often are applied in software industry projects. Based on this model and its artefacts, we exemplary identify the writing fields a software engineer has to process in his working area.

The artefacts delivered in each phase can be seen in Fig. 1. They are annotated outside of the connected phases on the left respectively the right side. Inside the v-model we put the communication instruments in day-to-day business. The first document to be created is the requirements specification, followed by the overall system specification. The artefacts of the system design phase are the system architecture, the system specification and the external unit specification documents. During the detailed design phase the concrete hard- and software architecture is specified in the hardware/software-specifications document. Documents might be titled in a different way in a specific project. Apart from this, a software engineer has to create a document that specifies the test cases in a test specifications document. Moreover, in each test phase a protocol of the performed tests has to be prepared. During the system integration test phase the logical support documentation has to be developed. Especially, documenting and writing tests (we do not mean the coded test cases here) such as usability

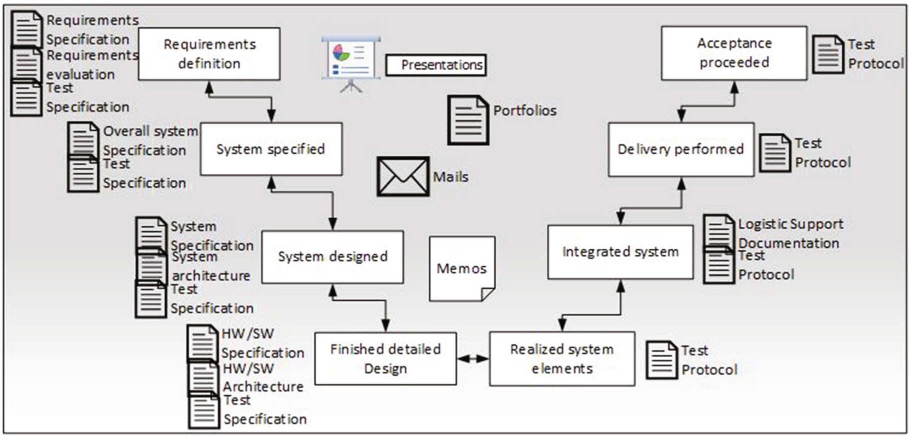

Fig. 1. The v-model 97 and a the artefacts a software engineer needs writing skills. Presentations, portfolios, mails and memos are additional tasks in day-to-day business where writing skills are indispensable for a software engineer [14].

tests force writing in different layers of conception, processing and evaluation of the test event [14]. Thus, we can identify about ten areas in the v-model 97 where a software engineer has to write down technical information, wherefore he/she needs adequate writing skills and of course technical know-how.

The v-model XT provides 13 product groups. Each group contains at least three documents where writing skills are necessary; either to develop a concept, to give a status update, for documentation, or to protocol [14]. The identified ten areas and 13 product groups always depend on the underlying project, process and its management. Due to the extreme tailoring (XT), the v-model XT takes different versions for each case. Therefore, we do not present a annotated model here. The number and different kinds of documents to produce, illustrate that to be skilled in writing in the domain of software engineering is highly relevant. A prerequisite to formulate comprehensible documents, is having linguistic ability. Writing skills are required and presumed in all applied software development process models. Obligated requirements concerning writing performance we clarify by the hand of the required documents during the traverse of the software development process.

6 Conclusion and Outlook

The motivated necessity and relevance to improve writing skills especially technical writing skills in the context of higher education has to be implemented on different levels. Numerous surveys and research projects focus on the necessity and possible conceptions to teach writing skills. Already, in 1999 Jakobs and Kruse state that the practical implementations proceed a very slow pace after the insight of the necessity to teach writing skills [3,15]. We approve this statement with regard to its up-to-dateness in form of a questionnaire-based survey as our next step. The acquisition of current writing activities in higher software engineering education is necessary to accompany the process of the development of professional formulation expertise. Following research questions are going to be focused on in a questionnaire survey:

– Which types of writing can be determined in the teaching of higher software engineering education?
– For which teaching contents are texts produced?
– Is there a feedback to produced texts?
– In what way is feedback granted?

It is possible to generate potentials for writing didactics systematically in software engineering on the basis of the needs analysis and already existing models in the research of domain- specific writing. For such a specific concept for software engineers, it is mandatory to take further conditions like the writer himself, the workplace, the organisation and the cultural environment beside the domain- specific conditions into account. With a holistic teaching concept which focuses on developing writing in profession, students recognize the importance of writing in their discipline.

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A Systematic Literature Review of the Application of the Jigsaw Technique in Engineering and Computing

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Abstract. Jigsaw is an active learning technique that consists in dividing a learning material into partial tasks, and each partial task is assigned to one member of a jigsaw team. Each student has to complete the assigned partial task and has to compare the results obtained with students of other groups that made the same partial task. Finally, one of these partial tasks, which eventually will end up integrated by all of the jigsaw team members. Although Jigsaw was originally designed for non-university students, the systematic literature review presented in this paper aims to summarize the experiences reported in 19 selected papers that show the application of the jigsaw technique in engineering and computing programs (undergraduate or graduate). Our findings suggest jigsaw technique can be applied in engineering and computing programs with good results.

Keywords: Collaborative learning · Active learning · Jigsaw technique · Systematic literature review · Engineering education · Computing education

1 Introduction

Active, cooperative, and collaborative learning focuses on the premise that the students can learn better by doing and working with their peers [1]. Jigsaw is an active learning technique proposed by Aronson et al. [2], and it was created to reduce racial conflict among school children.

According to Aronson [3], Jigsaw consists in dividing the day's lesson into 5 or 6 segments (e.g. a segment can be a piece of a short biography). Each student is assigned to one segment, and they have time to become familiar with their segment. Then students form temporary "expert groups" by having one student from each group join other students assigned to the same segment. Finally, students come back to their jigsaw groups to work together and to integrate their assigned segments.

Although the jigsaw technique was originally designed for non-university students, the purpose of the study presented in this paper is to investigate about the experiences in the application of jigsaw in higher education programs in engineering and

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computing. We have performed a systematic literature review to find these type of experiences.

The remainder of the paper is organized as follows: Sect. 2 describes the review process followed for the systematic review; Sect. 3 discusses our findings; and finally, conclusions and future work are included.

2 Review Process

Petticrew and Roberts [4] indicate "systematic reviews are literature reviews that adhere closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (of whatever design) in order to answer a particular question (or set of questions)".

A systematic literature review (SLR) is a kind of literature review that aims to identify, evaluate, and interpret all available research relevant to a particular research topic area or question. SLR is widely used in Medicine and, in the last years, in the Software Engineering field [5]. Although there are no specific guidelines to perform systematic reviews in engineering or computing education, we selected the guidelines for medical education presented by Cook and West [6].

2.1 Research Questions

The purpose of this work was to find experiences in the application of the jigsaw technique in undergraduate or graduate programs in engineering or computing. In this way, we formulated the following research questions:

RQ1. What evidence is there for the application of the jigsaw technique in engineering and computing programs (undergraduate or graduate)?
    RQ1a. What kind of programs (undergraduate or graduate) has applied jigsaw?
    RQ1b. What technique was used, the original jigsaw or an adaptation?
RQ2. What kind of results were obtained when they applied the technique?

In order to conduct this review, we defined the general concepts based on PICO (Population, Intervention, Comparison, Outcomes) method [6]. The definition of the general concepts through the use of PICO is detailed as follows: (Table 1).

Table 1. Definition of the general concepts using PICO

Criterion	Description
Population	Engineering or computing students (undergraduate or graduate)
Intervention	Jigsaw technique
Comparison	Traditional lecture or laboratory
Outcomes	Students improve knowledge or skills, good perception of jigsaw by students

2.2 Search Strategy

The search terms used in this study were developed using the following criteria: *(i)* Besides the term "computing", we considered the five defined sub-disciplines of the computing curricula proposed by IEEE and ACM [7]: "software engineering", "computer science", "information systems", "information technology", and "computer engineering" *(ii)* Include "informatics" as a synonym of "computing" *(iii)* Include "software development" because is a term widely used in computing *(iv)* Don't use only "jigsaw" as a string, because it provides many results unrelated to this learning technique (we could find out this issue when we did searches with "jigsaw"). The resulting string was:

("jigsaw technique" OR "jigsaw classroom" OR "jigsaw collaborat*" OR "jigsaw cooperat*" OR "jigsaw method*") AND ("engineering" OR "computing" OR "informatics" OR "software engineering" OR "computer science" OR "information technology" OR "software development" OR "information systems")

The string was used only to perform searches by title, abstract and keyword to avoid thousands of unnecessary obtaining results, according to the recommendations of Ryaz et al. [8].

2.3 Search Process

The search process was conducted using the following databases: Scopus, Web of Science (WOS), IEEE Xplore, and ACM Digital Library. WOS database used in this SLR contains the main collection of Web of Science, BIOSIS, Current Contents Connect, Derwent Innovations Index, Inspec, KCI, Medline, and SciELO.

2.4 Selection of Studies

The following inclusion and exclusion criteria were applied to the select publications:

Inclusion Criteria. *(i)* The study must report the application of the jigsaw technique in a course included in an undergraduate, or graduate program of engineering or computing *(ii)* Publication must be written in English, Spanish or Portuguese.

Exclusion Criteria. *(i)* Studies with experiences not related to higher education (undergraduate or graduate) in engineering or computing *(ii)* Publications without peer-review (e.g. prefaces, books, editorials, etc.) *(iii)* Conference papers that are extended as journal articles [9] *(iv)* Studies that shows the utilization of a software tool that supports jigsaw without the evaluation of the jigsaw technique.

The search process was conducted during November 2015 and was updated in June 2016. We obtained 88 results from the four consulted databases. After the application of the inclusion and exclusion criteria, 19 publications were selected. Table 2 shows the details regarding the amount of studies that were found during the search process.

At the beginning, screening of titles and abstracts for the potential studies was performed by the authors against the inclusion/exclusion criteria. If no decision could be made just on title and abstract, we had to examine full papers to make the decision. Table 3 gives the list of selected studies.

Table 2. Summary of Search Results

Database	Search results	Duplicated	Selected Papers
Scopus	34	–	16
Web of Science*	36	24	1
IEEE Xplore	16	10	2
ACM	2	1	0
Total	88	35	19

*Subscriptions: Main collection of Web of Science, BIOSIS, Current Contents Connect, Derwent Innovations Index, Inspec, KCI, Medline, and SciELO

3 Findings

According to research question RQ1, we could select 19 publications that confirm there is evidence of applying the jigsaw technique in engineering and computing. Table 4 shows the number of publications found for each kind of program (research question RQ1a).

As it can be observed in Table 4, the majority of the papers are in Computing (8 papers). Although most of the papers are focused on specific subjects of engineering, three publications are related to basic courses for engineers and computing professionals such as communications [10, 13] and physics [24]. All studies are regarding undergraduate programs.

For research question RQ1b, most of the authors apply jigsaw technique as it was proposed by Aronson. However, Fang et al. [12], Deibel [11], and Pow-Sang [21, 23] use adaptations of the jigsaw.

Fang et al. [12] adapts jigsaw to be used in laboratories with approximately 100 students. Each week one member of each jigsaw team attends to a laboratory session. After attending the weekly session, this team member meets with their respective jigsaw team and teaches the lesson.

Deibel [11] proposed and adaptation called "latent jigsaw." Latent jigsaw method skips the expert stage by utilizing the students' prior knowledge and opinions. Students are presented with a question that has multiple correct solutions and are asked to choose from a restricted set of answers. Once the answers are collected, the learning groups are formed by grouping together students who chose different answers.

Pow-Sang [21, 23] do not assign one piece of work to one student; it can be assigned to a pair of students that they have to work together in the whole activity.

According to research question RQ2, all of the authors indicate students had good perceptions about the cooperative work that they performed with the jigsaw technique, some of those authors show results of surveys or questionnaires [11, 14, 16]. However, only Tahir et al. [27, 28], Gomez et al. [13], Robledo-Rella et al. [24], Natarajan et al. [19], Pow-Sang [21, 23] show quantitative results which demonstrated that there was an improvement in student's learning.

Table 3. List of selected papers

Ref.	Title	Authors
[10]	Achieving excellence in technical communication classes by using IEEE Spectrum magazine & active learning techniques	D. Webb
[11]	Team formation methods for increasing interaction during in-class group work	K. Deibel
[12]	Improving engineering laboratory experience through computer simulations and cooperative learning	N. Fang, G. Stewardson
[13]	Cooperative learning applied to processing and production of texts [El aprendizaje cooperativo aplicado a la didáctica del procesamiento y producción de textos]	J.A. Gómez
[14]	Jigsaw learning technique: Addressing problems of implementation	H. Husain, et al.
[15]	A collaborative and adaptive design pattern of the jigsaw method within learning design-based e-learning systems	M. Kordaki, et al.
[16]	Jigsaw cooperative learning in engineering classrooms	M.A. Kousa
[17]	Cooperative learning in computer programming courses	M. Anton-Rodriguez; et al.
[18]	Experience of cooperative learning in engineering	R. Maceiras, et al.
[19]	Collaborative learning in an operating systems course: An experience report	S. Natarajan
[20]	Cooperative project-based learning for machine design in the industrial engineering program: methodologies and experiences	E. Perez, et al.
[21]	The jigsaw technique: Experiences teaching analysis class diagrams	J.A. Pow-Sang, et al.
[22]	Using JIGSAW-type collaborative learning for integrating foreign students in embedded system engineering	H. Posadas, et al.
[23]	Replacing a traditional lecture class with a jigsaw class to teach analysis class diagrams	J.A. Pow-Sang
[24]	Collaborative learning for physics courses at tecnológico de Monterrey, Mexico City Campus	V. Robledo-Rella, et al.
[25]	Innovative learning and teaching methodology in electronic technology area: A case of study in computer science university degrees	M.C. Romero, et al.
[26]	Implementing the jigsaw model in CS1 closed labs	L. Soh
[27]	The jigsaw cooperative method amongst electrical engineering students	N.M. Tahir, K.A. Othman
[28]	Case study of jigsaw cooperative learning effect within electrical engineering courses	N.M. Tahir, et al.

Table 4. Number of publications for program

Program	Number of papers	References
Computing	8 (42.1%)	[11, 15, 19, 21–23, 25, 26]
Electrical, Electronic or Telecommunications Engineering	5 (26.3%)	[14, 16, 17, 27, 28]
Chemical Engineering	1 (5.3%)	[18]
Industrial Engineering	1 (5.3%)	[20]
Manufacturing Engineering	1 (5.3%)	[12]
General Engineering	3 (15.7%)	[10, 13, 24]

4 Conclusions and Future Work

This paper will present the results of a systematic literature review of the application of the jigsaw technique in engineering and computing. 19 studies were selected, and they show the jigsaw was applied in laboratories and classrooms. Most of the papers utilized original Jigsaw; however, some authors use adaptations. The majority of the papers are applied in computing programs.

The effect of the application of the technique was measured using questionnaires, surveys, and tests. Studies show students had a good perception of the application of the jigsaw technique in their laboratories or classrooms.

It is planned as a future work to include other databases to find more papers related to the application of jigsaw. It remains as future work to check references and citations of the selected papers obtained in our SLR to find more studies.

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Designing a Competency Framework for Graduate Levels in Computing Sciences: The Middle-East Context

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Abstract. This paper focuses on the current research work done within the Pro-Skima project (2015–2018) which aims at providing a suitable method to evolve classical Information Technology Master graduate levels towards some teaching contents and a pedagogical organisation more adapted to the competency needs of local employers and Qatar Society in the field of new technologies. A first important step of the project is to define a method for building a competency framework for the Master curriculum. The aim of this paper is related to the first step of the project, i.e. to examine critically different possible methods that can be used for designing such competency framework and analyse what can be a realistic approach considering local specificities of Qatar University, characteristics of the technical field (IT) and possible partnerships with some surrounding companies.

Keywords: Competency framework · Curriculum development method · Master degree in computing · Collaborative research

1 Introduction

In several countries, universities and other academic institutions have over the years increasingly equipped themselves with competency frameworks. This corresponds to an important evolution of the goals traditionally assigned to universities and academics: not only produce and transmit scientific knowledge, but also prepare students for the workplace and more broadly for their professional careers [1]. Competency frameworks are part of different pedagogical tools used to 'vocationalise' academic training courses. Competency framework aims at describing typical activities, knowledge, attitudes and skills related to a type of job or function (or a field of jobs and functions) that are prepared by a training course. This first reference document, generally built in a partnership between academics, professional experts and sometimes representatives from companies and public authorities, is then used to define knowledge to be conveyed during a training course. The result of this process is formalised in a second document called training framework, which also often provide recommendations (or, in some cases, sets the requirements) with regard to the types and characteristics of

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training situations to be implemented in order to ensure acquisition of the various pieces of knowledge.

This referencing process of work activities, vocational knowledge and skills is closely tied to the increasing use of the concepts of competence in education. Research literature show that many definitions of competency have been proposed in different academic fields [2–6]. Beyond differences, it seems that a number of common traits appear in the empirical studies on the characteristics of competencies held by professional experts. They are highly contextual capabilities, specific to an occupation, professional field or set of work situations with common characteristics. They may be defined as the ability to apply a set of heterogeneous resources, which are either internal (theoretical knowledge, practical know-how, behaviour or attitudes, professional values) or external (technical subjects, organisational elements, written documents, other participants, etc.), in order to accomplish a certain kind of task. Identifying competencies related to a type job (or field of jobs) therefore requires analysing tasks and work performed in real work situations.

Competency-based education was initially developed in the United States, during the seventies, in response to growing criticisms towards education considered as more and more disconnected from the societal evolutions, especially changes within the workplaces [7]. Despite some criticisms, this type of pedagogical approach has been used in several western countries to reform upper-secondary vocational curricula. For some years, it appears to be more and more used in higher education, as a way to update and reform academic courses [1, 8].

Competency-based education is based on several principles: proposing a broader framework, based on real life or professional practices that are not organised according to a disciplinary principle but rather around a rationale of individual and social action; not only being interested in observable performance but in complex sets of knowledge, abilities and behaviour which are mobilised in combination to achieve these practices in concrete situations; establishing learning situations that are no longer organised according to a disciplinary principle, but instead structured around activities for problem-solving or case studies, which are often worked on collectively, requiring use of a wide array of knowledge not strictly limited to one discipline; defining methods and criteria for assessing the practical ability of students to cope with this type of situation, as a sign that they have developed the targeted competencies.

Despite this global development of competency-based education, many universities around the world have kept a very academic organization of their training courses. In a lot of countries, educational authorities consider as more and more problematic the gap between this still very academic approach and the increasing needs of complex competencies (knowledge, skills and attitudes), both in the economy and the society. Pushed by international organisations (like OECD, UNESCO, World Bank, European Union, etc.), they look for some ways to encourage academics to evolve towards more competency-based approaches and to get closer to the working world and more generally to the social concerns.

Qatar is a young country, with a high economic growth mainly based on oil and gas resources. But the public authorities were early aware that these resources will not last forever [9]. Consequently they invested a lot (and they still continue) in the education system, convinced by the idea of a very competitive future world, based on the capacity of countries to develop a knowledge-based economy. Qatar University is born in 1977, with the aim to contribute to this challenge. The academic purposes were largely privileged, with great success in the capacity to attract international researchers and to play in the academic competition. With the increasing development of both technical and social infrastructures in the country, the students need to be prepared to the new complex nature of the world of work.

The Pro-Skima project (2015–2018) [10] aims at contributing to this new challenge for Qatar University. Its goal is to provide a suitable method to evolve a Master of sciences in computing in Qatar University towards some teaching contents and a pedagogical organisation more adapted to the competency needs of local employers in the field of new technologies. This project is funded by the Qatar National Research Fund (QNRF) and based on a partnership between Qatar University and Lyon 2 Lumière University in France. A first important step of the project is to define a method for building competency framework for this particular Master course. The aim of this paper is focused on the first step of the project, i.e. to critically review different possible methods that can be used for designing such competency framework and analyse what can be a realistic approach considering specificities of the local University context (and more specifically in the computer sciences field), characteristics of the technical field (IT) and possible partnerships with some surrounding companies.

In the next part, we present the collaborative approach that we used to realise this step of the project. Then, we explain why different methods, which have been created to analyse professional tasks and jobs during the 20th century, had a great influence on curriculum development in pre-service vocational training, but are not well adapted as such in. In part 4 and 5, two specific methods developed for building vocational training curriculum are presented and their relevance is discussed for tertiary courses. Finally, we explain the reasons why we chose one method that we adapted for evolving the curriculum of the master of sciences in computing in Qatar University towards collaborative learning.

2 A Collaborative Approach

The Pro-Skima project is based on a collaborative approach, involving researchers in social sciences (sociology, vocational didactics), researchers and teachers in IT (especially those who teach in the Master degree, or manage this training course), and representatives from companies that have growing recruitment needs in this field of competence (IT) and want to develop a partnership with QU. This interdisciplinary and collaborative approach is necessary considering the aim of the project, which is to evolve an academic curriculum in the field of computer sciences, towards a stronger professionalization perspective and more collaboration between academics and professionals. Such a goal requires not only academics in the technical field of computer sciences, and others in the research field of education, but also workplace practioners and representatives from companies.

Collaborative means that we try non only to develop an external analysis about the pedagogical organisation of the Master course and its surrounding environment (types and characteristics of jobs related to this master and possible companies who offer them), but also to include a deep understanding about the way how the different practitioners (Head of the department, Dean of the college, Researchers and teachers who give some lessons, professional experts and representatives in the corresponding field of the master) act and think in their respective local context, developing particular goals, using some resources and managing local constrains. As quoted by an increasing number of researchers in education [11, 12], collaboration of researchers and practioners is essential in order to develop a progressive and common understanding of a complex set of social practices and organisations (university and companies). This shared understanding is also a key point for transforming and getting closer these different worlds of practices.

"The traditional relationship between researcher, the producer of knowledge, and practitioner, the user of knowledge, was replaced by a commitment to the notion of two sources of knowledge (research and practice). Though the two sources might generate somewhat different types of knowledge, both types are judged to be of equal value and importance to improving educational outcomes" [11, p. 461].

To build such a complex and common view, the project team uses and combines various types of data in a multi-situated ethnographic perspective [13, 14]: academic literature review (especially about competency framework building methods), observations in different locations (university and within some companies), collection of pedagogical and vocational documents, interviews with academics and professional experts, etc. But we not stay in a classical observation position. We initiate and organise also some specific events (meetings both in different companies and at university, workshops) to meet and bring together the different stakeholders and engage them in a joint work. This engagement with practitioners answers both to the pragmatic (implementing jointly a new competency framework) and scientific goals (producing new knowledge on curriculum development) of the project. A first important pragmatic aim is to develop a common acceptation and understanding of the problem, considering the initial gap between academic practices and company needs. The next phase is to build collectively a competency framework about IT jobs. Researchers in Social Sciences bring different possible competency framework building methods found in the literature. Academic experts in computing sciences and representatives from the government and from companies bring their expertise about the technical, social and organisational aspects of IT jobs. Teachers of the master courses bring their knowledge and experience about the curriculum organisation and academic constrains. But researchers engage themselves in joint action with practioners not only to help them building a new competency framework and adapting the curriculum. New situations generated jointly provide also access to specific behaviors, reactions and representations that are interesting to study in a social science perspective. More precisely, our general research issue during this project is to study and better understand the social process of negotiation between different actors leading to evolve the curriculum of the master in a certain direction. In this sense, the competency framework building process that we have initiated is an excellent field of study.

3 From Work and Job Analysis to Competency Frameworks Development

The literature in industrial and organisational psychology, as well in ergonomics and sociology of work, shows that there has long been a rich tradition of analysis of work and jobs, with many schools of thought and a variety of methods used to carry out these analyses [15]. Various definitions have been proposed. Here are three, for purposes of illustration: "Job analysis is the process of collecting, organising, analysing and documenting information about work." [15, p. 219]; "A wide variety of systematic procedures for examining, documenting and drawing inferences about work activities, worker attributes and the work context." [16, p. 21]; "Work analysis can be defined as the systematic investigation of: (a) role requirements, and (b) the broader context within which work roles are enacted." [17, p. 4].

The first work-studies developed at the beginning of the 20th century were focused on production operations (goods or services) and aimed at streamlining the organisation of work. This type of approach, developed by F.W. Taylor and F. and L. Gilbreths for instance, consisted in carefully observing the tasks performed by workers and analysing them into unitary movement components in order to reduce unnecessary or ineffective gestures and find the most effective sequences. Thereafter, many methods were elaborated for various purposes such as: creating a documentary base about jobs for providing similar information to employers, HR specialists, workers, trainers, etc. in one country[1]; designing tools for assessing candidate during a recruitment process or evaluating employee in a company; constituting a reference base for defining the internal training needs of a company; etc. From initial concerns, which were very focused on elementary tasks analysis in order to improve the productivity of work, we moved towards much more various purposes (information of stakeholders, assessment, continuous training, etc.) and a broader scope: from tasks to complete functions or jobs, in order to describe them in terms of a set of typical tasks and related knowledge, skills and attitudes used to perform them.

When the competency-based approach developed in the world of education, particularly in upper-secondary vocational training courses and later, in specialised tertiary courses, it is not surprising then that training designers retained a number ideas and methods to build their own reference frameworks, as highlighted by Rauner: "A crucial influence on curriculum development is exercised by the various task analysis methods that were developed, especially in the United States, as a basis for competency-based training." [18, p. 365].

[1] A good example of this is the *Dictionary of Occupational Titles,* which has been created in the fifties in the US. This is a very comprehensive system of information on all types of jobs existing in the country that is now available in the form of a public website accessible to all (http://www.onetonline.org). To carry out this work correctly, many analysts were recruited and trained to conduct thousands of worksite visits across the United States and record their field observations. The great advantage of such a system is its ease accessibility to all (employers, employees, trainers, political institutions, etc.), thus providing them with similar information, facilitating coordination with other types of stakeholders and allowing for comparison between very different occupations or functions [14].

However, a major limitation of many of the methods used is their cost in time and human resources required to achieve descriptions of tasks and sufficiently comprehensive and realistic competencies for a given profession. Another difficulty is that vocational training is decreasingly restricted to a single type of business or function. Evolution in the professional world towards an increased differentiation of occupations, but also the growing demand from employers for flexibility, adaptability and evolution from their employees into related functions, has prompted training professionals to expand the job prospects of their sectors [19]. In Germany for instance, where the vocational training system has long been organised into sectors closely correlated with specific trades, the need arose to revise the national qualification system towards more transversal training. These developments have made the creation of reference frameworks more complex and thus less restricted to the analyses of tasks specific to one type of job or profession, instead being required to uncover more transversal tasks and competencies.

For these reasons, the methods used by researchers (work psychologists, ergonomists or sociologists of professions of instance) or HR specialists to analyse work are rarely integrated as is. They are either too local, either too time-consuming and either too costly in resources, or all of the above. When occupational descriptive systems (qualification frameworks) exist at a national level (as in the Dictionary of Occupational Titles in the U.S. or the National Vocational Qualification in England for example), training managers can certainly rely upon this basis to develop their curricula. However, it is often necessary to build on such systems with a more detailed analysis of a type of occupation or function but not, as mentioned above, delve into as much detail as in the methods discussed previously. Approaches were therefore developed to more quickly provide resourceful, valid reference frameworks in terms of existing professional practices and associated competencies. Several approaches can be cited, but two seem particularly popular internationally. In the following lines, we present these two approaches before focusing on their relevance for university courses in the subsequent section.

4 A Functional Analysis Approach

A first example of this type of method specifically oriented towards a vocational training purpose is based on concepts and practices from the management sciences. In this field, the functional analysis tool is employed above all to analyse production processes as a set of activities to be performed and that can then be carried out by different functions, themselves split across different departments [20]. When this approach is applied to develop competence frameworks, as was the case for example with the European project NAME (Analytical Nomenclature of the European Multimedia) [21], an initial definition is provided of a certain type of production process of goods or services. It is then divided into as many activities and tasks (an activity comprises several tasks) as needed to achieve the established goals. The next step consists of identifying the various types of professionals performing such tasks and subtasks and determining whether that particular task is part of the core competency or else secondary (see Table 1). Next, in compiling all the activities and tasks for a given

Table 1. Job analysis (by activity and task) [21, p. 14]

Process description		Job description			
Activity	Task	Job 1	Job 2	Job 3	Job 4
Activity 1	Task 1.1	1	2	0	0
	Task 1.2	2	1	0	0
	Etc.	…	…	…	…
Activity 2	Task 1.N	0	2	2	1
	Task 2.1	0	0	1	1
	Etc.	…	…	…	…

occupation, the various competencies required for their completion are described. In the following example, taken from the NAME project, the technical, conceptual and human dimensions have been distinguished along with other relevant personal skills (attitudes, personality traits, etc.) falling under these competencies. This distinction has been based on the work of R. Katz on decision-makers [22]. We ultimately derive a framework describing all the activities and competencies related to a given production area, broken down into different professions (e.g. project manager, graphic designer, trainer).

In the NAME project, the information necessary to develop the reference framework was collected by different means. A study was first conducted to identify, in each country concerned by the project, the titles and contents of occupations or jobs in the multimedia sector. In most countries, somewhat older reference frameworks already existed and were used as sources to list the tasks and identify job titles. Project participants established a table similar to that presented in Table 2.

Table 2. Competency analysis for one type of job [21, p. 15]

Process description		Competencies			
Activity	Task	Technical	Conceptual	Human	Personal attributes
Activity 1	Task 1.1	TC 1.1.1 TC 1.1.2	CC 1.1.1 CC 1.1.2 CC 1.1.3	HC 1.1.1	PA 1.1.1 PA 1.1.2
	Etc.	….	…	…	…
Activity 2	Task 2.1	TC 2.1.1 TC 2.1.2 TC 2.1.3	CC 2.1.1 CC 2.1.2	HC 2.1.1	PA 2.1.1
	Etc.	…	…	…	…

This model served as a collection and structuring tool for the information gathered during interviews with professionals in the companies visited. A statistical study identified recurring activities and tasks in the various workplaces and allowed establishing a list of all constituent activities and tasks of the process, as they related to different trades. To analyse competencies, project stakeholders based their work on existing standards across different countries and completed the first information source via interviews with a number of targeted experts. A combination of methods was thus used in this case: both existing documentary sources and new information on the activities, tasks, occupations and competencies via specific workplace interviews and online questionnaires completed by professionals in the field within the various countries. The range of information collected was cross-referenced so as to enrich the descriptions as well as strengthen their relevance in a maximum number of cases. No direct observations were recorded of professionals at work, as this would have proved too costly and complex. When research based on empirical observations does exist however, it can also serve as input for designer reflection on frameworks.

5 DACUM

A second widespread framework construction method is DACUM (acronym for "Developing A CUrriculuM"). This methodology emerged during the second half of the 1960's in Canada, specifically at Holland College, Charlottetown on Prince Edward Island. It was then increasingly applied in various Canadian vocational training institutions and exported, beginning in the 1980's, to many countries on all continents (South America, Asia, Europe, Africa, Australia) [7]. In the 1990's, R. Norton perfected this method at the Centre on Education and Training for Employment (CETE), College of Education, University of Ohio. He published several reference guides on this approach [23]. A training course and website have also been set up to ensure its dissemination and mastery of the developed methodology.

This method is based on three premises, summarised as follows by Norton:

"(1) Expert workers can describe and define their job/occupation more accurately than anyone else. Persons who are working full-time in their positions are the real experts on that job. Even though supervisors and managers usually know a lot about their subordinates' work, they usually lack the expertise for a high quality analysis. (2) An effective way to define a job/occupation is to precisely describe the tasks that expert workers perform. A successful worker performs a variety of tasks that either the customer or employer wants performed. Possessing positive attitudes and knowledge alone are not enough. Hence, finding out what expert workers (top performers) do will give us the opportunity to prepare other experts. (3) All tasks, in order to be performed correctly demand the use of certain knowledge, skills, tools and positive worker behavior. While the knowledge, skills, tools and worker behavior are not tasks, they are enablers which make it possible for the worker to be successful. Because these four enablers are so important, considerable attention is given during the DACUM workshop to identifying lists of each. Because these attributes are different and distinct from the tasks, it is very important to keep them separate if a high-quality analysis of job performance is to be obtained." [23, pp. 9–10].

The DACUM is also characterised by its speed and low implementation cost. It can be used at different scales to analyse a family of trades or professions, or else a single trade or profession, a function, a role or a professional position. All skill levels can be studied, from task execution occupations to engineering and management. These qualities explain its widespread use around the world, in comparison with other work analysis methods, which require time and human costs. The method is mainly based on brainstorming in small groups with experts of an occupation or job field (5 to 9 experts considered exceptional or outstanding), according to a process of very carefully organised steps and led by a trained facilitator, assisted by a "recorder", i.e. a person who records and notes all exchanges. The role of the facilitator is to explain the method, move through the process by questioning and facilitating discussions (consensus-building, management of any disagreements or conflicts, etc.). Two or three days are required to achieve a complete description of the occupation, depending on the complexity therein.

The different group work stages are as follows. The facilitator begins by asking the experts to provide a name, definition and scope for their trade (or field of trades). A discussion is then held to mutually find a name and definition. The experts are then asked to identify their duties, also called competence fields. The instruction might be as follows: "Please identify the major (big) pieces of your occupational pie." The definition of a mission is: 'a general area of competence that successful workers in the occupation must demonstrate or perform on an on-going basis. An exchange between experts must lead to an agreement on a finite list of missions. The facilitator helps the experts formulate such missions as follows: verb, modifier, and noun. For example, a manager's mission may be: 'Implement (verb) training (modifier) programme (noun)'.

For each mission, the experts identify a series of tasks, subtasks and operations (with each level being fitted into the previous one). A task is defined as follows: "a work activity that has a beginning and an end, is observable, consists of 2 or more definite steps, and leads to a product, service or decision". Again, each task, subtask and operation must be described in the format: "verb-modifier-noun".

This format must be strictly observed to ensure the consistency of the repository and provide a clear basis for curriculum developers in their subsequent use. The experts are then asked to identify, for different missions, tasks and operations: knowledge, i.e. understanding and familiarity with facts and information; skills, i.e. the ability to perform occupational tasks with a high degree of proficiency; traits, i.e. an innate or learned ability or distinguishing quality that allows an individual to complete a job.

During the next stage, the facilitator coordinates the experts during a series of exercises so that they define the most essential tasks ('criticality of each task') in their profession and the most common ones ('frequency') or the ones that consume the most time. The experts are then asked about the current and future training needs of the profession, both for employees with the most seniority and younger professionals. Finally, the facilitator invites those present to evaluate the process they have just experienced. They also receive a certificate of training in this method before leaving. The results of this effort can then be used as a framework to design training. The developed levels (occupation, missions, tasks, subtasks, knowledge, skills, and traits) provide information for the various aspects of design engineering as follows (Table 3).

Table 3. Levels of DACUM analysis

Level	DACUM analysis		Training
1	Jobs title, job definition, scope of the study	… Used to identify …	The training programme audience
2	Duties (skills or fields)	… Used to identify …	The programme's general aim and objectives
3	Tasks (or specific skills)	… Used to identify …	The programme's learning modules
4	Subtasks	… Used to identify …	The specific objectives of a learning module, as formulated in terms of expected performance
5	Operations or key actions	… Used to identify …	Performance indicators (PIs), incorporating the criteria to be met and the various components of competencies to be mastered
6	Knowledge, skills, personal traits considered most essential		

6 Benefit and Limit of Introducing Competency Framework Building Approaches in University Courses

In a competence-based training approach, the two methods described in the previous sections are deemed to be relevant and applicable to all types and levels of training: initial, secondary, higher, or further education. In reality, they have been more widely used in continuing education for adults and, to a lesser extent, at the secondary level (their use is currently expanding at this level) than in university courses. Even when the aim is to prepare young people for occupations (middle management, engineers, managers), at this level considerable reluctance is expressed to align content and training methods so radically with existing business practices.

For example, Postiaux, Bouillard and Romainville [24] demonstrated this in a recent study on the framework building process in 10 higher education courses (mainly engineering) in France, Belgium, the Netherlands and Canada. They based their work on documents and interviews held with designers who, for the most part, were the teachers of the courses in question. Their analyses highlight that all frameworks are not organised into a competence-based approach, such as the description of a set of actions or tasks performed in a certain type of professional context, combined with the knowledge, skills and attitudes or behaviours that enable completion of these actions. Instead, some formulate learning objectives, which may also be rather vague, e.g. to become a critically thinking, reflective and independent professional. Furthermore, when asked about the reasons for reference framework construction, many designers indicate the need for a coordination tool among teachers, which may also serve to better inform students about the objectives and course content, develop new educational approaches, streamline evaluation methods, etc. In summary, a framework is constructed to a lesser extent for these teachers to have a clear reference on the professional practices they prepare and more as an internal educational tool. Others also justify this work by the obligation to comply with changes in the European higher education sector (Bologna process). According to the designers interviewed, the introduction of these frameworks in 10 courses studied has produced a handful of real effects. In most cases however, this has not led to a higher level of course professionalism, but instead merely served to better coordinate and reorganise the course content in a more rational and less redundant way.

Consequently, it seems that while the reference framework construction practice has become increasingly common in higher education, it is less of a framework for professional activities and skills and more of an educational framework. In current engineering training, the construction of the former occurs prior to that of the latter. The training reference framework is also assumed to stem in large part from the activity framework. In fact, the first step, if not avoided altogether, often seems to be completed quickly without necessarily any contribution from professional experts of the considered occupation. Moreover, whether in secondary or higher education, even when professionals are present for reference framework construction cases, they tend more often to be representatives with an HR, managerial or union profile rather than real experts of the occupation in question [18].

Does it then become appropriate to implement such occupational reference framework construction approaches for higher education courses? The authors of this study would answer “no” if we were speaking about a project to strictly align the training objectives and content with the needs and practices of the professional world. This perspective challenges the university culture of academics, who are concerned over allowing anything other than the acquisition of professional skills. An extremely important objective is the transmission of knowledge based on research, coupled with the development of critical thinking and independence among young people. Such qualities can also be very beneficial for employers, perhaps not in the short term but certainly in the medium and long term. Another argument limiting the interest of a strict correspondence between training and existing occupations is that graduates’ careers are becoming less predictable: many fulfil functions will be quite different from their initial training [25]. The same applies to occupations that, as already mentioned, do not consist practices, which are fixed but rather evolving. Some occupations are emerging, while others have yet to see the light of day. These potential activities must be driven by young graduates with the skills to invent and develop them.

Despite these arguments, we can still consider that the construction of reference frameworks describing occupations or jobs linked to a curriculum remains a valuable approach for at least two reasons. First, it is often the process itself, which brings together professionals and teachers that is as beneficial as the final result (the framework). This process allows both worlds (academic and professional) to get better acquainted with one another, which offers the advantage of sharing developments on both sides: the professional practices and needs of one side, and the advances in research on the other. These contacts and improved understanding can also, secondarily, contribute to coordinating academic teaching and training periods for example.

Moreover, this effort can help identify and involve professionals to a greater extent in schools and universities, to assist teachers.

Second, an activity and skill framework, when properly constructed with the assistance of expert professionals in the field, constitutes a possible reference for building the training framework. This should not be the only one however, for the reasons mentioned above (training must also depend on academic knowledge, e.g. combined with recent research), and it would be foolish to deny this. The establishment of a joint body (academic and professional) to consider changes in the training reference framework (knowledge content, training situations, assessment methods) is an interesting proposition from this point of view because it offers the possibility to discuss and negotiate the respective share of more academic contributions and more professional training situations into the curriculum and how to marry both of them. One might even consider hybrid situations, in the form of innovative projects promoting transfers from academia to the professional world and vice versa. Let's add that the activities and skills reference framework construction approach for a higher education course not only describes existing practices by investigative methods such as those used in the DACUM approach, but also helps expand the study of documentary sources that further the research of future developments in certain professional fields.

7 Building a Method Adapted to the Case of the Master of Sciences in Computing in Qatar University

The two reasons developed in the previous section seem to be valid in the case of the Master of sciences in computing of Qatar University. It is extremely important that academics and representatives from both companies and ministries can deeply and frequently discuss about the pedagogical evolution of this master, which appears as very strategic for the current and future economic development of Qatar. Indeed, this country started to build large-scale infrastructures (ex: healthcare system, banking systems, logistic facilities, industrial estates, etc.), which all require powerful, interrelated, ergonomic and secured information systems. We interviewed several representatives from companies and IT ministry, and some technical experts (professionals and researchers). They all underlined that the competency needs in the field of IT will largely increase in the next years in the perspective of a more digital-based economy. The cyber-security subfield will be especially crucial to secure all the already set up complex Information Systems and those which will be implement soon.

This extremely qualified labour need cannot be satisfied only by expatriate experts, many of them do not stay permanently and durably in the country. It is also a matter of national sovereignty: Qatar has no sustainable interest in outsourcing strategic dimensions of its national security and sovereignty (e.g. SI safety of the banking and financial sector, or water supply system) to foreign companies. Consequently, it is very important for the country to increase its capacity to train very qualified experts in this IT Field, especially in cyber-security. Qualified means experts who are both well informed about real workplace problems and able to solve efficiently and quickly these problems. This is in not possible to prepare such experts only by providing them some technical knowledge and skills. We interviewed one expert in cyber-security, who worked previously for big

European companies in the Banking field and is now a consultant in the IT Ministry. He explained us that students should acquire additional courses in applied psychology and sociology to be able to understand the hackers' psychological profiles and their social behaviors, as well as the practices of users of IT systems. Experts from IT companies we have interviewed also confirmed this point. They also stressed the importance of integrating internships in the training curriculum of the master course to learn how to work for real customers in IT development teams. Let's add that jobs related to cyber-security are quite new and are changing fast, both in terms of technical and social competencies. So, it is very difficult to describe stable work practices, which can play a role of sustainable references for designing a training curriculum. Students must not only acquire knowledge, skills and attitudes related to the existing workplace practices, but also be in contact with research knowledge and activities to be able to play the role of boundary actors between academic and economic spheres and invent innovative cyber defence practices to answer to the continuous challenges posed by hackers.

All these points highlight the compelling necessity of a deep and frequent dialogue between different types of actors for designing curricula in the IT training field. Academics, technical experts and managers from companies, representatives from public authorities have all a strong interest in working conjointly to design curricula. This is probably the only way to answer correctly to both current high-qualified labour needs and to well prepare graduates to answer to the future big socio-economic and technical challenges of Qatar. Setting-up a balanced committee, composed of these different types of actors, which aim is to build a competency framework and then a training framework, appear as an interesting way to provide a mixed space for constructive dialogue between different social worlds (university, companies, government) and to evolve the Master of sciences in computing towards a better relevance for the economy and the society of Qatar.

The specificities of the jobs and functions involved, especially their rapid evolution, is a key issue in choosing a building/updating method of a competency framework, which is relatively quick to implement. As we saw previously, a lot of work analysis methods are time consuming and costly in human resources. In several countries, such as France, it takes an average of two full years to build or update competency and training frameworks. In addition, commissions that perform this work are often very institutional and policy, with representatives from national unions of employers and employees. Such an approach is unsuited to Qatar, to the extent that the unions do not exist or little. A more local commission seems much more preferable.

8 Conclusion: The Choice of the DACUM Approach

Considering all these reasons, it seems that a method based on the DACUM approach is quite well adapted in this case. As we said previously, this is a method: with a low implementation cost in time and human resources (3 or 4 days, with 5 to 9 experts to build a complete competency framework and then a complete curriculum); that has proven to be very efficient in different cultural and business contexts; which can be used at different scales to analyse a family of trades or else a single type of job, function, role or professional position. This great flexibility is very interesting when the boundaries of a vocational field/trade are not well defined, as it is the case in some subfields of computer sciences, like cyber-security. But, we think also that some adaptations of the basic method are necessary. Indeed, in such a new and unpredictable vocational field, it would most likely be complicated and irrelevant to build a reference framework only from existing practices. It is more worthwhile to work not only with professional experts, but also to integrate researchers during a second time, to try jointly imagine the jobs of tomorrow that will make up a large component of the reference framework. To advance the thinking in this area, a documentary review could also be carried out and added to enrich the analysis made by professional experts and researchers, in particular via the Web (existing worldwide repositories and training, prospective studies of the area, etc.).

Furthermore, there is a more opportunistic reason to choose DACUM. During the first 6 months of the project, we establish an interesting connexion with the Swiss Federal Institute for Vocational Education and Training (SFIVET - http://www.ehb-schweiz.ch), which use a method strongly inspired from the DACUM (with some adaptations) to design and update the curricula of all the different existing vocational training courses in Switzerland, both at post-secondary and tertiary level. An expert from this institution already came in November 2015 in Qatar University to contribute to a first international workshop. He presented the method used in Switzerland. Both teachers of the master and representatives from partner companies critically discussed this method comparing to others. It seemed to every one that it could be easily adapted to the Qatari context for building a first competency framework for the Master of sciences in computing, which can be used to update the master curriculum afterwards. One interesting point is that the Swiss method allows including both current practices and future evolution in the vocational field. As we said previously, this is a critical point for IT jobs, especially in the subfield of cyber-security tools and technics (a growing need in Qatar), which is rapidly changing.

The next step of the project will consist in organising a second workshop, managed by this Swiss expert, with professional and technical experts, representatives from companies and academics to concretely develop such a competency framework for this Master. A social organisation (joint committee) will be also created to regularly update this competency framework and adapt the master curriculum.

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Analyzing Students' Knowledge Building Skills by Comparing Their Written Production to Syllabus

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Abstract. The field of Learning Analytics (LA) focuses on the collection, measure and analysis of data about learners and their contexts. LA benefits from tools that are normally rooted in probabilistic/frequency-based approaches, which are themselves incapable of capturing the meaning of texts at any level because probabilities do not constitute a natural language semantics. As alternatives to these approaches, Natural Language Processing (NLP) techniques allow the integration of semantic aspects into the analysis. In this study, we aim to evaluate the coverage of the syllabus vocabulary in students' documents using a method based on linguistic and cognitive knowledge. Our analysis is conducted using an asymmetric coverage hybrid measure, which combines semantic and lexical information with cognitive principles to determine how syllabus concepts are covered in students' documents. To determine whether the concepts of a book are covered by the paragraphs in the students' documents, we implemented a paragraph-to-document alignment strategy. This approach distinguishes between stronger and weaker productions by measuring the degree of concepts coverage between students' papers and multiple sections of the syllabus.

1 Introduction

Over the last decade, Learning Analytics (LA) has emerged as a means to quantitatively analyze the Learning' process. Mostly, LA focuses on frequencies of participations, contributions, amount of references, etc. [1]. Taking into account recent advances in Natural Language Processing (NLP) and Text-Mining (TM) techniques, it is now possible to incorporate new models within LA, in order to study the development of new concepts by students within knowledge-building approaches. Recent works on the analysis of learners' dialogues in Computer-Supported Collaborative Learning (CSCL) platforms have shown that various linguistic and cognitive phenomena are involved in learning processes [2,3].

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This study explores the coverage of concepts from syllabus documents in students' reports. In this endeavor, we automatically detect the interaction between students' documents and the syllabus. Our data set is composed of four formal productions (reports) covering the assessment of 5 European Credit Transfer System (ECT) study credits. An analysis is performed based on a similarity measure from [4], and the alignment of students' documents with scientific literature is based on [5].

The results indicate that certain concepts found in the literature are mentioned in the students' reports. It should be noted that the reports are included in the official student assessments. A weak coverage-concept document from a student that did not pass the teacher's assessment was also detected by the analysis. We conducted a member check evaluation with independent experts in order to get feedback. Participants suggested that our analytic approach could be used to provide a quick overview of the ability of each student to acquire important concepts.

2 Background

Recognition, learning, and judgment are examples of mental cognitive processes where humans categorize stimuli in terms of similarity. As such, we suppose that everything is part of a set of objects that share common characteristics. As the main object for this categorization, similarity has been studied in philosophy and psychology as a symmetric relation [6]. In his 1977 study, Tversky demonstrated that similarity for humans is, in most cases, an asymmetric relation.

2.1 Symmetric Similarity vs. Asymmetric Similarity

Most works covering computer science have focused on similarity measures as a symmetric relation [7]. These similarity measures were conceived symmetrically because of the use of geometric spaces, such as VSM, and the bag of words model for cosine similarity, in the context of NLP. When comparing two objects, A and B, in a coordinated space, the similarity between them is symmetric because the distance is always the same from object A to object B, and vice versa. However, in Tversky's [6] view, similarity is an asymmetric relation, which is better described as a comparison of features (matching processes) rather than a computation of metric distances between two points. Tversky [6] also mentions that the concept of symmetric similarity should not be rejected altogether; it holds in many contexts, while in many others, it is a useful approximation.

2.2 Similarity Measures for Text Processing

Sentence similarity is, in fact, a process that combines word similarity measures to express how similar two sentences are. Word similarity measures are usually classified into two groups: those that are lexical-based, and measures that use language resources (e.g., Lin's measure [8] using WordNet [9]).

In the first group, the most common approach consists in measuring the cosine angle between two vectors. That means the concept of distance is used, and therefore, the relation is symmetric.

The cosine similarity approach has several known improvement strategies: using n-grams to construct vectors, removing stop-words and some content-words (adjectives or adverbs), lemmatizing words, etc.

In the second strategy, we find measures that use knowledge resources to compute the similarity between two concepts. For example, WordNet, a lexical database with a network structure, is widely used to create such measures [9]. Meng et al. [10] review some of WordNet's similarity measures.

The literature provides some efforts aimed at merging both groups, with a combination of the lexical and taxonomic similarity computations between two sentences. Mihalcea et al. [4] present a semantic similarity measure for short texts, which combines lexical-based and knowledge-based measures.

3 Methodology

We collected four student's documents $\{1, 2, 3, 4\}$ from a (Med) course at Stoas — Vilentum University of Applied Sciences and Teacher Education in the Netherlands. The documents were produced by three different students $\{A, B, C\}$. We collected fifteen documents suggested in the students' course syllabus. These documents comprised scientific papers, book chapters, and entire books. All the syllabus documents were written in English. The students' documents were originally written in Dutch. We then used Google Translate to translate all the documents into English. Of course the tool is not as efficient as a human professional translator, but provided material that was good enough to allow our analysis [11]. To process the students' documents and syllabus texts, we divided the texts into paragraphs, which allowed us to process texts of similar lengths. We also extracted stop-words. Finally, we made carried out alignment using two lexical measures and our asymmetric coverage hybrid measure (ACHM). We adapted the hybrid measure presented in Mihalcea et al. (2006) [4] to make it asymmetric. The original measure selected the word that contributed the most to the similarity between two texts. Retaining this characteristic, we present the new adapted measure in Subsect. 3.1.

First, we used two strategies to compute the lexical similarity, with the cosine similarity measure as the baseline. We then used a lexical similarity measure based on Dice's coefficient.

3.1 Asymmetric Coverage Hybrid Measure (ACHM)

As Tversky [6] states, similarity involves an asymmetric relation, where the subject of comparison is more similar to the referent, and not vice versa. This is because the referent has more features than the subject of comparison.

For us, the subject of comparison is a student's text, composed of one or more paragraphs, whereas the referent is any text from the course syllabus.

We hypothesize that a text from the course syllabus is richer in the use of vocabulary (features). Considering this, we evaluate the vocabulary coverage of syllabus concepts in the students' documents. We only used the first term of the formula proposed in [4] to keep the asymmetric direction of comparison. The final formula is presented in (1):

$$sim(R, S) = \frac{\sum_{w \in \{R\}} maxSim(w, S) * idf(w)}{\sum_{w \in \{R\}} idf(w)} \tag{1}$$

where R is the referent and S is the subject of comparison. The function *maxSim(w, S)* selects the word that contributes the most to the similarity between R and S. We omitted the second term of Mihalcea et al.'s formula because it ranks R and S at the same level of importance, see [4]. Our hypothesis is that in the comparison process, the elements of comparison do not play the same role, and as a result, they need to be treated differently.

3.2 Alignment of Students' Texts vs. Syllabus Texts

Our method is inspired by the text alignment method proposed in Beamer and Girju [5]; the authors align slides to scientific papers using a cosine similarity measure built over a TF-IDF matrix. We retain the main idea, and align short units of text to a bigger unit, replacing the measure by our ACHM measure. Because we were interested in the influence of the syllabus text on the students' texts, we aligned paragraphs of the students' documents with each document from the syllabus (also decomposed into short paragraphs). For each paragraph in a student's document, we computed the similarity between each paragraph within a syllabus document. We then selected the paragraph that had the maximum similarity value with the student's paragraph. To determine if a paragraph was aligned to a document, we fixed a threshold. Consequently, a student's paragraph could of course be aligned with more than one syllabus document.

4 Results

We present our results using histograms in Figs. 1, 2, and 3. These figures show how many times a syllabus document was aligned with students' documents. The students' documents are presented on the x-axis. The y-axis displays the number of times the corresponding syllabus document was aligned with the students' documents (Single Document Alignment Occurrences or SDAO). In Fig. 2, for example, Book 1 was aligned 20 times with document 1, which in fact corresponds to our student A. The black line, in each graph, represents the average of all SDAO, which we will refer to as the Multiple Documents Alignment Average (MDAA).

Using this visualization, we can infer which syllabus documents influenced each student the most. Figure 1 shows the cosine similarity approach that we considered as a baseline. In this figure, we can see that for document 1 (student

A's first attempt), three syllabus documents reach the MDAA. For document 2 (student A's second attempt), one syllabus document exceeds the MDAA, while the other three barely reach it. In comparison, for document 3, most syllabus documents amply exceed the MDAA. The problem arises when we analyze document 4. The figure shows clearly that only one syllabus document reaches the MDAA, a situation even worse than in document 1. Nevertheless, we know that document 4 corresponds to a very successful grade, which is not the case with document 1. With this approach, we see that document 3 has more syllabus documents aligned with its paragraphs and that the frequency of the alignment is relatively high. However, using this measure, it is difficult to determine the most influential documents for each student.

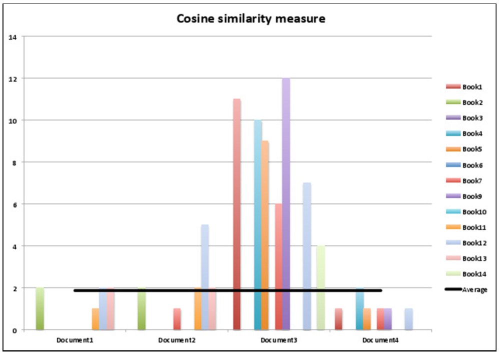

Fig. 1. Number of times that each student's document was aligned to each syllabus document using the cosine strategy. The black line corresponds to the Multiple Documents Alignment Average.

Figure 2 shows the performance of the approach based on Dice's coefficient. In this case, the MDAA is very high (black line); almost all syllabus documents are aligned. It is easy to see that this visualization does not allow further analysis.

Finally, Fig. 3 presents the result of our ACHM measure. Document 1 (student A's first attempt) has 5 documents that exceed the MDAA (black line). If compared with the rest of the documents, the number of paragraphs aligned (y-axis) is lower. Syllabus Books 9 and 12 are the most influential for this student's document. Regarding document 2 (student A's second attempt), the number of paragraphs that exceed the MDAA is significantly higher. For document 2, the most influential syllabus documents are 4, 6, 9 and 12. Document 3 presents 6 documents that exceed the MDAA. The most influential syllabus documents for document 3 are 4, 6, 9 and 12. Document 4 presents one syllabus document that reaches the MDAA and 4 syllabus documents that exceed it. The difference between document 4 and document 1 resides in the number of paragraphs aligned (y-axis); document 4 has greater values than document 1. The most influential syllabus documents are 4, 9 and 12.

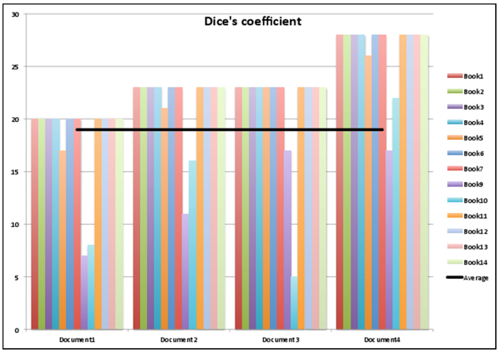

Fig. 2. Number of times that each student's document was aligned to each syllabus document using the Dice's coefficient strategy. The black line corresponds to the Multiple Documents Alignment Average.

5 Discussion

Many studies have analyzed students' documents, with most of them focusing on the various types of productions completely during classes (dialogues and discourse on CSCL platforms), but not on final productions [2,3]. For example, Sorour et al. [12] presented a method to predict students' grades based on Artificial Neural Network and Latent Semantic Analysis. They used only free-style comments written by students after each lesson to make their predictions. In contrast, we compared students' documents as final productions with syllabus documents without the intention of predicting the students' grades. Instead, we analyzed the use of concepts from syllabus documents in students' documents. Scheihing et al. [3] classified the discourse of students on a CSCL platform.

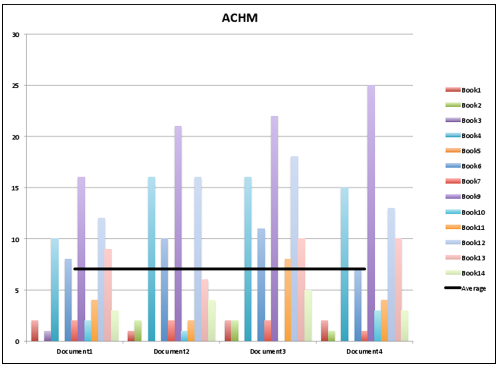

Fig. 3. Number of times that each student's document was aligned to each syllabus document using the ACHM strategy. The black line corresponds to the Multiple Documents Alignment Average.

They analyzed the interaction of students and teachers through dialogues by evaluating correlations between discursive attitudes and other variables linked to the learning activity. They applied the Jakobson theory about the function of language [13], which allowed them to infer qualitative information about the learner's progress and engagement, which can then be used by the teacher to take any decision in the activity. It is interesting, here, to note that linguistic theories are applied in building a model. In our case, we use linguistic knowledge in the computation of text similarity based on WordNet information.

We conducted a member check evaluation with teachers; they corroborated that our approach was able to find documents with missing information as compared to other documents. One of the participant stated: "*in documents 1 and 2, the student has difficulty in grasping concepts*".

6 Conclusions

We present an NLP approach applied in an LA context to analyze students' discourse knowledge as crystalized in their formal written productions. To that end, we propose an Asymmetric Coverage Hybrid Measure. Our approach is robust in the sense that we implement some linguistic and cognitive knowledge in the design. Our measure was able to detect a weak use of concepts in a student's document. For the same student, the approach evaluated a better coverage of concepts for the document that was approved in the assignment. Our approach is promising because by using linguistic information, we can obtain a finer interpretation of the data that frequency-based approaches skip. Our future work will focus on refining the coverage measurement used to make comparisons, in a bid to detect the order in which the concepts were originally written. We will conduct a quantitative evaluation of the results, using a greater amount of data. We also want to incorporate the references cited by students that are not included in the original syllabus' list of documents.

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Advanced Training of Engineers in Research University: Traditions and Innovations

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Abstract. This article focuses on innovation processes in the additional professional education of engineering staff based on contemporary government education policy, updated technologies of training and interdisciplinary approaches. Kazan National Research Technological University (KNRTU) experience on the development of advanced training programs has been offered as a positive model in cooperation with partners.

Keywords: Advanced training · Engineering education · Government program · Distant learning technology

1 Introduction

A government program of advanced training of engineering staff becomes an original educational phenomenon and an efficient model of public-private partnership in Russia. The development of educational organizations in this area got strong support as a result of a new government policy in engineering education and became a new educational project. It is known that one of development peculiarities of education system in Russia is compulsory government organizational and financial support based on federal regulatory legal acts involving regional government and business institutions [1]. In advanced training of engineering staff this support was provided with the Presidential program of advanced training of engineering staff for 2012–2014 (Program P) in 2012 and was first focused only on engineers of industrial enterprises.

Many Russian industrial organizations have estimated advantages of advanced training system offered by the Program P and are trying to organize their staff training in a similar format. KNRTU and enterprises of Kama Innovation Regional Industrial Cluster (KIRIC) cooperation in the Republic of Tatarstan of the Russian Federation is used as an example. Support Program of KIRIC in 2013–2016 (Program K) and necessary co-financing using budget funds make it possible.

Advanced training system at KNRTU is presented in a number of publications [4–6]. However, the fresh impetus of its development due to government programs always provides data of study. This article is dedicated to analysis of minor program development and their influence on education activities of universities and increase their interaction with business partners.

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2 New Experience and Its Development

The Program P became the key document indicating inevitability, need, and efficiency of equal state participation, education, and business in the formation of professional engineering elite. 2/3 of its implementation was financed with the federal budget. 30% of the cost of the Program, or 50% of the budget costs were financed by the enterprise, via reimbursement for travel expenses and expenses on internships. Program structure included lectures and practical studies (more than 72 h), final assessment, internship in Russia (to 50% of students), and internship abroad (to 30% of students).

Table 1. Changes in the involvement of Russian higher educational establishments and industrial enterprises in the Program P (Presidential program of advanced training of engineering staff for 2012–2014).

Advanced Training Programs	Period	Students, quantity	Internships in Russia, quantity in people	Internships abroad, quantity in people	Educational Organizations Taking Part in the Program, quantity	Implemented Programs for Advanced Training, quantity	Enterprises are customers of the Program, quantity
Program P	2012	5209	1252	472	96	161	1361
	2013	6364	3462	1116		213	
	2014	5001	1042	643		170	

According to data in Table 1, 15000 students have been trained on advanced training programs, more than 4500 engineering specialists have had internships at enterprises and engineering centers of the Russian Federation and also about 2000 specialists have been trained abroad. For three years of this program, the advanced program bank amounted to 544 programs from 96 educational organizations who have applied to take part in, passed an examination and won the contest. 1361 enterprises of real economy were advanced training program customers in 2012-2014.

Since 2014 the Program has changed its status. It has been transferred into the supervision of the Ministry of Education and Science in the Russian Federation (Program V) [7]. At the same time structure of the educational program did not change, it includes theoretical and practical training (72 h), internship of 20% of students in enterprises and Russian scientific centers, 10% of students are sent abroad for internship. However, financial burden is shared equally now. An amount of co-funding corresponds to federal budget expenditures (Table 2).

General quantitative indicators decreased regarding the results of the Program V in 2015 and due to the plan in 2016. In 2015–2016 8040 specialists have to be trained. 1609 people have internship in Russia and 803 trainees are abroad. This setback can be explained by the decline in a budget. Unit cost of programs remained unchanged.

66 educational organizations became winners in 2015. Advanced training program bank has included 195 advance training programs. 424 enterprises became customers

Table 2. Changes in the involvement of Russian higher educational establishments and industrial enterprises in the Program V (Program of Advanced Training of Engineering Staff for 2015–2016).

Advanced Training Programs	Period	Students, quantity	Internships in Russia, quantity in people	Internships abroad, quantity in people	Educational Organizations Taking Part in the Program, quantity	Implemented Programs for Advanced Training, quantity	Enterprises are customers of the Program, quantity
Program V	2015	3850	771	384	69	195	424
	2016	*4190*	*838*	*419*		*32*	

despite the fact that the contest was announced in July when it was impossible to change enterprise budget due to new tasks and orders.

Table 3 shows changes in the proportion of programs on priority directions of the Russian Federation in the development of science, technology and technique [8].

Table 3. Changes in the distribution of career development programs among the priority growth areas in science, technology and engineering.

Priority directions	2012	2013	2014	2015
Energy efficiency and energy saving	43%	39%	48%	31%
Transport and space system	9%	14%	11%	21%
Information and communication systems	19%	21%	17%	17%
Advanced weapons	11%	15%	16%	14%
Science about life	5%	4%	2%	5%
Nanosystem industry	7%	5%	3%	3%
Nuclear power	6%	2%	3%	2%
Sustainable environmental management	–	–	–	9%

As you can see, the overall indexes of the past years have been preserved. The majority of applications on the following trends "Energy Efficiency and Energy Saving "were filed." Transport and space systems" field causes growing interest. From our point of view, positive change could also affect the direction called "Advanced Weapons". However, according to the existing restrictions in the interest of safety and the protection of national security information, not all the enterprises of the military industrial sector may perform an obligatory condition of the program which is to send employees to train abroad. Sustainable Environmental Management is a new trend in the list of basic directions where entries have also been applied.

The changes also affected groups of learners as well. Now not only engineering specialists, but also technical experts can be learners (on the Russian scale). Besides, master's degree or postgraduate students can be the participants of the program at the training stage. Program teachers belong to groups taking part in internships.

Research carried out by the authors since 2013 allows to estimate positive changes in the activities of KNRTU in advanced training of engineering staff. It also provides an opportunity to reveal the continuity in organization of educational process through 4

Programs (P, V, K, and G, it will be told about the last one below) and their impact on university education as a whole.

The University has participated in the Program P since 2013. 7 minor programs of advanced training have been implemented for 2 years within the framework of the Program. Participation in these Programs helped to improve skills of professors themselves. It gave the opportunity to study advanced experience at world's leading scientific and educational centers, powerful enterprises and to develop education technology.

These programs demand a new approach for training, as they all are qualified specialists who want to master technologies and experience of an enterprise or the leading foreign scientific and educational center. The customers also censoriously evaluated proposed programs in terms of development of professional competences of students and their acquisition of new qualifications. All the programs were being developed due to a possibility of their use in the key teaching process for KNRTU students.

Experience of the Program realization showed that university professors also require acquisition of new competences and vocational skills in according to modern education, science, production demands, customer and student needs. Therefore, the university sent the best professors to internship in groups who go to Russian enterprises and foreign countries in the framework of the Program initially through university budget funds.

A new format of the Program V set a number of pedagogical problems. It is possible to train engineers and technical specialists within the framework of the same Program, although it is essential to form different groups. Full-time or part-time students also can be trainees in this Program. Participation of students and the necessity of identical final competences formation by different groups of students resulted in development of flexible adaptive education technology. They are successfully implemented by Program professors according to estimates of students in final surveys and letters of appreciation of enterprises-customers.

Eventually, the study showed the necessity of evaluating implementation practice of programs P and V at the university due to the results of monitoring in the Russian Federation. So, it is no coincidence that National Training Foundation published a 60-page document on general rules of reporting. University autonomy have to be combined with the state, society, and corporate customer interests.

3 Regional Innovations at the Federal Foundation as a Result of University Activity

The authors will compare eighteen programs developed at the university in 2013–2016 in the framework of implementation of public policy of advanced training of engineering staff. Afterwards, recommendations on development of advanced training programs will be prepared for mixed categories of students. It provides the formation of necessary competences for employers based on professional standards. Consumer participation in program funding in the format of private-state partnership presents consistent development of contractual relationships even if there is a lack of further public funding. The Federal subjects of the Russian Federation also create new models of private-state partnership based on positive experience described above (Table 4).

Table 4. Changes in the involvement of the higher educational establishments and industrial enterprises of the Republic of Tatarstan, Russia in the Program K (Support Program of KIRIC in 2013–2016)

Advanced Training Programs	Period	Students at the KNRTU, quantity	Internships in Russia, quantity in people	Internships abroad, quantity in people	Educational Organizations Taking Part in the Program, quantity	Implemented Programs for Advanced Training, quantity	Enterprises are customers of the Program, quantity
Program K	2014	180			3	7	69
	2015	319		20	3	10	69
	2016						69

As mentioned above, tens of enterprises in the Republic of Tatarstan are grouped in KIRIC. Their industry specialization is petroleum and gas refining, petrochemistry and car industry. The special role of innovation education clusters in region development is interpreted by advantages of the cluster as an integrating element of concerned parties in order to improve economic efficiency and region competitiveness. The creation of such clusters is connected with the necessity of joining organizations on particular criteria for specific purposes. Thus, the Program K involves the formation of long-term demand and region's enterprise interest to innovations through training programs of professional development. It also means strengthening their position in the domestic and foreign markets. As the main activity of this cluster is the petrochemical and refining industries, KNRTU plays a special role in solving its problems. This higher education institution is one of the leading universities in this field, both in the region and in the country as a whole. KNITU is also the leading university of industry academic cluster It integrates primary, secondary, higher and additional professional education (minor program education) and innovation of the Republic of Tatarstan in petrochemistry. The University has consistently defended its position, according to which the higher education institution should be a base for continuing professional education for industrial enterprises, because it has significant experience in training, and research in various fields, especially in chemistry, petroleum refining and petrochemistry, nanomaterials, etc.

It is known that employee training and retraining is one of the key elements for effective development of enterprise and the industry as well. Project-based learning is extremely important for innovations. The Program of KIRIC development has the following differences: firstly, organizing advanced training of organization staff participating in the cluster and secondly, advanced training is carried out not only on traditional 72-h-programs but also long-term (from 250 h) professional retraining that gives an opportunity to get new qualification or profession.

On the basis of the educational course structure of Programs V and P, developers of the Program K have involved theoretical and practical trainings (72 h) in their content, not less than 20% of trainees in enterprises and research centers of Russia and not less than 10% in world scientific and industrial centers. Funding is distributed as follows: 90% of costs is from federal budget (to support KIRIC) and 10% is from enterprise.

In 2013–2016 KNRTU trained employees of KIRIC on 7 programs (2 of them) for more than 200 specialists from companies belonging to the cluster. One of the most popular programs is “Modern Polymeric Nano composites”. It has its meaning. Firstly, polymer composites production and processing is specialization of the vast majority of KIRIC enterprises. Secondly, the program above is included in the database of the best Russian programs within the framework of the Program P implementation. Thirdly, this Program is implemented every year. It allows to compare training results when changing the number of students after course modification (for example, to form specialist innovation competences that are not provided by basic educational standards).

This Program includes an internship in Federal State Unitary Enterprise “All-Russian Scientific Research Institute of Aviation Materials” in Moscow. It is the leading center on polymer composites in Russia. Visiting specializing academic center “COMPOSITEC” (Savoie technolac, France) was organized for training abroad.

It should be pointed out that programs of continuing professional education have integrated nature. They are implemented in the context of the cluster and according to the CDIO approaches [10, p. 421]: All the programs are developed according to the preparation and implementation of programs for continuing professional education of enterprise staff in the production field based on the national research University and taking into account customer requirements in relation to specific productive realities [11, 12]. Modification of minor programs for KIRIC specialists. Enterprises of this cluster are focused on the innovation. Programs of continuing professional education involve a number of methods and educational technologies that are aimed at developing creative skills. They teach how to respond to problems, to work in a team and individually on particular projects, to search decisions in situations of uncertainty or risk, to interpret results and other constituents of innovative competence.

Focus on innovation implies competences in perception and reflection as well as modification and introduction of new ideas. Procedures aimed at developing these two aspects of the competence can be used in areal sense. On the one hand, efforts must be directed towards improving individual sensitivity to new and unusual things and, on the other hand, developing abilities to use, modify, adapt, implement and distribute creativity results [13].

Interactive training was also intensified for achieving this goal. Programs of continuing professional education involved workshops, master classes, flipped classroom followed by discussions. Professors use educational technologies that allow to differentiate and individualize the program, to make it more flexible and adaptive due to the needs of customers and enterprises. They are problem-based learning, modular training, project-based learning, and collaborative learning.

The course “Training Innovative Interaction in the Work Group” is included in many programs as a primary unit based on the experience of training students from different organizations. Its main issues are:

- preparation for forthcoming training;
- developing intra-group communication;
- creating out of box educational environment;
- motivating to learn;
- awareness of the need for the development of innovation capabilities in terms of professional activity at the enterprises of the cluster.

The program includes lectures, case study based on real production and oriented on solving problems, motivational business role-playing game, teamwork, group discussion, and etc.

A problem has revealed during the implementation of these programs. A program coordinator (The Ministry of Economy of the Republic of Tatarstan) has no wish to finance advanced training of university professors who are participants of the cluster. This position is partly due to current legislation. The government is responsible for advanced training of educators. It provides essential financing of higher education institutions. Therefore, the institutional body that is responsible for economy management in the Republic gave preference to advanced training of enterprise employees.

4 A New Format of Education Innovation

The formation of the program bank using distance learning technology has been an important result of the University cooperation with its partners-customers on the development of innovation processes in education. Defining KNRTU as a basic higher education institution of OJSC "Gazprom" and developing the collaboration based on annual donation agreement with the corporation (Program G). The application of distance learning technology is necessary. It is a specific feature of most programs implemented within the framework of the Programs P and V.

The creation of advanced training programs such as "Automated processing systems and production", "Corrosion and Pipeline Protection", "Measurement Assurance of Automation Facilities", "Operation and Maintenance of Compressor Plant Equipment" has been carried out from December, 2015 to April, 2016. Electronic academic support was prepared for each program and posted on the specific education information environment that is called "The System of Distance Learning" http://idpo.kstu.ru.

Many professors of the leading universities and practitioners of OJSC "Gazprom" subsidiaries were involved to prepare electronic academic support to test programs. There were 13 people. The only professor from beginning to end has developed one of the programs. Others have included units prepared by 5–7 professors. As advanced training programs described above, all the programs for "GAZPROM" are of strong interdisciplinary nature.

12 subsidiaries of OJSC "GAZPROM" from Krasnodar to Sakhalin expressed their willingness to participate. Participants presented their preferences and suggestions for further work. They are also available on the website. Implementing innovation education technology was not easy for students. 13 from 83 applicants have not started to train. 6 students have not completed the course.

At present new offers are being prepared on all the directions presented above.

To sum up, the most important thing should be noted. KNRTU program quality and its work have done in 2013–2014 was confirmed by orders from partner enterprises for 2015 on the threshold of an announced program V. In spite of economic crisis in 2016 University order was increased on advance training programs based on co-funding and as a part of Programs K and G. Not only import substitution policy, but also a sustainable high rating of programs among their students became the reason of it. Mixed groups of students, a combination of topical scientific and applied issues, the use of modern educational technologies, database of internships in leading Russian and foreign centers let you simulate the unique content of educational programs, accumulating interests and opportunities of all concerned participants. It promotes sustainable development of the University and its partners.

This situation absolutely corresponds to the CDIO initiative, so far as all the necessary elements are implemented within the same directed educational process: These elements are changing content and organization of the educational programs in various engineering areas, balance between practical and theoretical study or project-based learning as a means of acquiring skills in teamwork [10, p. 422].

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Quality of Study Programmes or Quality of Education

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Abstract. A philosophy glossary says that quality is an attribute or a property. According our common sense, usually we speak about better or worth quality. In both cases, the quality depends on either subjective feelings or objective facts and on the criteria being applied to. We discuss in this paper the term "quality of education" and critically compare different definitions of this specific term. We consider education as a universal public good, entity, determined quality in the philosophical sense. However, the term "quality of education" suppose comparison and assessment or measurement of value and management of quality. Often the quality of study programmes is in use instead of that. Then the theory of total quality management helps to improve quality. Known that assurance is its important part.

Keywords: Quality assurance · Study programmes · Higher education · Engineering education

1 Introduction

We often use the word "Quality" in ordinary life to show the non-inferiority or superiority of something but it is also a philosophical term. Ancient and modern philosophical schools interpret differently the term "Quality". First, it means an attribute or a property, second it is a philosophical category that distinguish one object or phenomenon from others and give it certainty. The same about "Education". In a different context, it means the process of education, its result, or an education system. We discuss in this paper the word combination "quality of education" according to different explanations of the both words in comparison with "quality of study programmes". There is no doubt that it is important to compare the quality of educational processes in different institutions, also to monitor the process, and to assure it. In the way, we speak about the quality of study programmes. However, we emphasize that education is a universal public good but the comparison of quality refers to the service sector. We argue against considering education only as a service.

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2 Terminology

There is different terminology in traditions of scientific schools, countries etc. In an English philosophy glossary, we can see that quality is an attribute or a property. It is obvious that the quality depends on either subjective feelings or objective facts and on the criteria being applied to. The quality of something do not determine its value. For example, somebody thinks something is good because it is useful, but others think something is good because it is beautiful, or simply because it exists. Therefore, next step is to find out what is useful, what is beautiful and what exists. According to our common sense, usually we speak about better or worth quality. In other words, quality can mean degree of excellence of something. In this case, we approach to the value of this.

In Russian philosophical dictionary [1], we can read the other definition: “Quality is a philosophical category that expresses the set of essential features, characteristics and properties that distinguishes one object or phenomenon from others and gives it certainty. The quality of an object or phenomenon, as a rule, is not reduced to its individual properties. It relates to the subject as a whole, covers it completely and is inseparable from it. Therefore, the concept of quality is associated with the Genesis of the subject. The subjects cannot lose their quality themselves”. In short, quality is something that defines the subject. From this point of view, “water” is a quality like an object in our mind but really, water is salted or unsalted, clean or dirty etc. Such concept as education is contradictory. Someone means here the process of education, someone - the result, and someone else - an education system.

We discuss in this paper the term “quality of education” and critically compare different definitions of this specific term. We consider education as entity, determined quality like a philosophical category. However, the term “quality of education” suppose comparison and assessment or measurement of value and management of quality. Often the quality of study programmes is in use instead of that. Then the theory of total quality management helps to improve quality. Known that quality assurance is its important part.

3 Discussion

In this part of the paper, we argue the importance of higher education at all and engineering education particularly. Social scientists use the term “the knowledge society” in our post-industrial era [2]. First, it means that society should use knowledge to improve the human living condition. Second, it means that manufacturing of high-tech products is the priority. Often mass media name modern society as information and communication one. It is true because many people use different gadgets to explore Internet and to communicate each other. However, the scientists warn that in parallel the world’s capacity for creation of raw data has significantly increased. Therefore, they insist on the necessity to construct the knowledge society on the base of modern communication possibilities. It means that the role of education will continue to grow and will be changed. It is not just about primary or secondary education as a basic human right; in the knowledge society education is not restricted to this level. Internet allows learners to seek information and to develop knowledge at any time and at any place where access is available and unrestricted. Only higher education may help them to classify and sort information. The number of applicants to higher educational institutions has increased steadily worldwide in the last two decades. For example in the Russian Federation the total amount of universities' students in 1995 was 2790.7 thousand; whereas in 2008 it increased to 7513.1 thousand; and in 2014 – to 5209.0 thousand [3]. Apparently, the reason for this consists in the intuitive awareness of the importance of higher education in our days. We do not analyze in this paper socio-economic impacts (positive or negative) associated with the increased part of people with higher education. Of course, active and critical use of Internet resources is the best way to lifelong learning that became actual according to continuous innovations in our époque. However, information can become "non-knowledge" without reflection and critical thinking.

The dates 3–14 of June 1992 we consider as the starting days of "the beginning of sustainable development movement". At these days, the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro [6]. The main issues of the Conference was as follows:

- "systematic scrutiny of patterns of production — particularly the production of toxic components, such as lead in gasoline, or poisonous waste including radioactive chemicals,
- alternative sources of energy to replace the use of fossil fuels which delegates linked to global climate change,
- new reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smoke,
- the growing usage and limited supply of water".

It is the engineers who can solve above-mentioned problems; that is why it is necessary to pay special attention to engineering education. During the World Engineering Education Forum (WEEF 2015) [4] a special term of "resilient society" was in use. It means (1) that it is necessary to attract public attention to the problems and (2) that the society development must follow the way of sustainability. In this case, the critical thinking and professional engineering analysis of all data must exist against alarmism. Therefore, humankind thinking about its safety and prosperous future and about adequate answers to above-mentioned challenges must consider education as a public good. All citizens regardless of whether they pay for it or not can consume public good collectively and they have the right to an adequate explanation of the problems and their solutions. In this case, the term "quality of education" applies to the national education system. In accordance with the reasoning, we can evaluate the quality of engineering education by the results of sustainable development implemented in the country. National education system consists of institutions. It is clear that the quality of its component parts determine the total quality. The driving force behind the struggle for quality consists in the competition that exists between universities. Number of students determine the financial situation of a university regardless of the source of its funding. Consequently, the market of educational services formed with all market attributes such as competition. The existing competition in the global and national markets of educational services requires a system for the correct orientation of consumers in this market. There exist several international systems of university ranking but each system has its own shortcomings. We suppose that the real way to create the system of consumers' orientation consists in further development of accreditation procedure for educational programmes: official (state), public or public-professional one. In the époque of globalization, international recognition of accreditation methodologies is necessary. In this case, the term "quality of education" applies to an educational process or to the results of the process.

4 Justification

Only a few words below are about the official criteria and accreditation process of study programmes because the national laws provide it. The public accreditation and quality assurance system is under consideration in the paper. When we try to assess an educational institution or a study programme, expectations of all interested parties (IP) or stakeholders may be the main criterion.

In the state funded institutions in Russia, the Federal State Education Standards (FSES) of study programmes in higher education are implied. These Standards describe all aspects of the educational process and establish the correspondence between learning outcomes and competencies developed. The Law on Education in Russian Federation states "the quality of education is a number of system-social properties and characteristics which determine the conformity of the education system to adopted requirements, social norms, and to the state educational standards". It is the main point of the state accreditation of study programmes. Only graduates of accredited programmes receive a state recognized diploma. On the other hand, employers expect to receive specialists trained in according to the industry standard; and the task is to provide the correspondence of educational and industry standards.

As stakeholders of higher education, we consider students and their parents, graduates, employers, governmental agencies, etc. Of course, they are all interested in the results of education but each of them has its own interest. For example, students and graduates want to find a good job after graduation as well as their parents. We observe two important reasons of the growing quantity of applicants of higher educational institutions: (1) national wealth in developed countries enables families to send young people to high school; (2) social mentality turns to understanding of the importance of higher education. We interpret these circumstances as (1) the favorable economic situation in the postindustrial society and (2) as understanding that education is a universal public good. The last falls in contradiction with the fact that after entering a university a student and his/her parents become a consumer of the educational service or, in the other words, a stakeholder. Nevertheless, there is a fine line between a service consumer and a person engaged in self-development. The first one is waiting for the result but the second one is engaged in the process and the result comes itself. Each of them has his own opinion about the quality of education as well as the above-mentioned stakeholders. Nevertheless, we do not see contradiction because the process determines the result and the study programme defines the course of the educational process.

The authors of the paper take part in the implementation of the International Tempus project "Online Quality Assurance of Study Programmes" (EQUASP).

The project deals with the development of a system of the online quality assurance of study programmes for engineering and technological education. The work is in progress and will be finished this year. We discussed in our previous paper [5] that implementation of the project meet peculiarities of the higher education systems in the countries participants of the project and difficulty of the terms translation. We suppose that it is necessary to prepare special vocabulary for better mutual understanding.

We have shown above that we cannot give a definition for the term "quality of education" but we are sure that really quality education can create awareness, meaning and understanding in a human being. For example, we can see the result of quality engineering education in the systematic movement towards resilient society. We understand that accreditation of study programmes and its assurance is not a panacea in the way of improving quality of engineering education. Nevertheless, it is a real instrument in the stakeholders' orientation. Presumable significance of the EQUASP project results is the movement towards constructing the resilient society. Anticipated result of the project consists in the improvement of quality of study programmes in Russian technical universities.

5 Conclusions

A few previous annual WEEF forums were devoted to sustainable development and resilient society as the global problems. In Europe, these topics became the mainstream while constructing European Higher Education Area (EHEA). The implementation of the results of the EQUASP project will bring the process of quality assurance of study programmes in Russian engineering education to the correspondence with the European Standards.

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Socio-Psychological Readiness for Academic Mobility of Engineering Students

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Abstract. The goal of the given study was to develop, justify and test pedagogical conditions for effective formation of socio-psychological readiness for academic mobility (SPRAM) of engineering students. SPRAM of engineering students is studied as an integrative personal characteristics that includes stable motivation; psychological knowledge and skills; self-regulation and self-management mechanisms; need for application of the acquired knowledge of technologies and methods; professional competences and language proficiency; abilities for independent performance, planning and effective implementation in the academic and working environment; capability to communicate successfully, resolve social situations and choose relevant communicational strategies.

The findings of the study allow concluding that the suggested pedagogical conditions for SPRAM development are efficient and helpful for the training of global engineers. The findings show that the engineering students' SPRAM considerably improved when the suggested model was implemented.

Keywords: Socio-psychological readiness · Academic mobility · Engineering students

1 Introduction

One of the main tasks of the national educational systems is to improve marketability of universities and their graduates and to adjust professional training to the all-European and global requirements. Therefore today professional education has to be continuous and mobile to meet the demands of community and the educational needs of a person. In the contemporary globalized community labor mobility of engineers and academic mobility of engineering students become specifically important for the development of global technological environment. To achieve this comprehensive task it is necessary to provide high level of professional knowledge, skills and competences, good language skills and a set of personal qualities, such as: willingness to change, sociability, collaborative skills, strive for self-improvement and life-long learning, stability of motivation and flexibility of behavioral strategies, open mind and some other personality characteristics. Altogether these parameters form socio-psychological readiness of engineering students for academic mobility.

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Academic mobility as a social phenomenon is widely studied by scholars and practitioners. Recent researches (2005–2015) address organizational and administrative issues of the development of academic mobility, informational and other resources to provide the mobility process. However psychological aspects, i.e. development of socio-psychological readiness for academic mobility of engineering students has not been thoroughly researched. Therefore the goal of the given study was to develop, justify and test pedagogical conditions for effective formation of socio-psychological readiness for academic mobility (SPRAM) of engineering students.

2 Approach and Research Concept

Bologna Declaration implementation in the European higher educational systems puts the emphasis on the high-quality training of students (including engineering students) for the future professional performance, and focuses on their socio-psychological readiness for the academic and professional life outside the university [1]. Mobility has become the key factor of the global technological progress [2]. To be mobile for a student means to be able to manage his/her own learning performance, to build up the personal educational trajectory, to realize educational needs, to project his/her future professional career and to be flexible in the rapidly changing professional environment [3–5].

Therefore the aim of professional educational is to provide good professional skills and to teach a student to manage various socio-professional situations, because many employers put their demands in terms of the personnel's knowledge and 'modus operandi'. They pay attention to such traits as team working skills, readiness for life-long learning and self-development and problem solving.

Literature review showed that efficient academic mobility of engineering students requires a complex of several elements [6]. Readiness for academic mobility means not only ability to study at an international university. International acknowledgement of diplomas does not guarantee the marketability of a university graduate at the global market place. Regardless of geographical, educational and political environment, nowadays readiness means comprehensive professional competence of an engineer. In this regard his readiness for academic mobility becomes crucially important and means a whole set of competences: professional knowledge and skills; second language proficiency; personal qualities needed for mobility. To be able to apply his professional and linguistic competences in the mobility context a student needs some personality characteristics: openness for changes, sociability and cooperativeness, ability and need for self-improvement and self-education, stability of motivation and flexibility of behavior, and openness for the new knowledge and technologies [7–9]. Altogether these traits may be defined as socio-psychological readiness of engineering student for academic mobility (SPRAM).

Thus training for academic mobility may be considered as an integrative system that includes professional education (technological, project-oriented, administrative or managerial training depending on the professional specifics), learning of foreign languages and development of personal qualities, motives and skills that comprise socio-psychological readiness that plays an important role in the student's academic mobility (Fig. 1).

The literature analysis revealed that SPRAM of engineering students has the following structure [6]:

- Motivational component. Stable intrinsic motivation for academic mobility, readiness for solving challenging social, professional and academic situations;
- Cognitive component. Knowledge and information that form the basis of SPRAM.
- Personality performance component. Socio-psychological traits necessary for efficient performance and successful interaction of the future engineer in the mobility context.
- Communicative component. Sociability, team working skills, conflict management skills, friendliness and other communicational characteristics necessary for successful academic mobility.

Each component of SPRAM of engineering students may be developed differently. Thus it is possible to determine the qualitative changes in the SPRAM development basing on the following three levels of SPRAM formation: critical, average and productive:

- *Critical level.* Students have only general overview about academic mobility, about contemporary professional context, about knowledge, skills and competences in engineering and learning performance. Students do not show initiative and motivation to percept new ideas. Their creativity is low and there is no strive for self-development and adequate self-evaluation.
- *Average level.* Students understand the significance of integrative processes in the European and global engineering education. They have superficial ideas about research activity and very basic skills of project inter-university collaboration. Their knowledge and skills appear only under standard educational conditions. Their interest for academic mobility and self-development is not stable. Self-evaluation is partially adequate.
- *Productive level.* Students show profound knowledge and skills in research and project activity. They are able to outline their educational trajectory independently basing on the level of industrial development and educational technologies. Students manifest innovative thinking, high motivation, openness for the innovations and at the same time demonstrate ability for rational and pragmatic analysis. They have high creativity, team-working skills, activity and initiative, good motivation for self-development and adequate productive self-evaluation.

Theoretical analysis displayed the necessity to elaborate and implement a set of pedagogical conditions for the development of SPRAM of engineering students.

3 Pedagogical Conditions for the SPRAM Development

The study of engineering students' social expectations in the course of professional training showed the necessity to elaborate the pedagogical conditions for the SPRAM development at an engineering university. The following conditions were distinguished in the process of the given research:

1. Gradual development of SPRAM in the educational process at the engineering university. Every stage of education is characterized by a prioritized component to be developed.
2. Development of engineering students' motivation for academic mobility, positive emotional attitude towards education and towards the chosen profession. This condition was implemented due to organized activities of mentors and tutors of the students' groups. Experimental group had various events: group discussions and individual talks, meetings with experts and simulation exercises, e.g. "My profession as my choice" and "Up the staircase of life or my lifetime plans" to develop intrinsic motivation for the engineering career in general and for academic mobility in particular.
3. Actualization of Hamanities' potential within the engineering majors to develop the skills of career planning, career development and activity in the future profession. This condition was implemented while students were taught Social sciences and Humanities according to the State Educational Standard, and enhanced by introduction of the authors course "Psychology of success" and by the minor degree programs on Psychology, Education, Economics, Management, Marketing and Human resources.
4. Personal development through learning was provided by formation of proper academic environment: students were engaged into extra-curriculum research work at their departments, participated in students conferences, published papers, issued student newspapers, made individual projects, etc. These tasks were aimed at developing assertiveness, self-management and managerial skills, sense of purpose, social responsibility, research motivation, and ability to handle stress, i.e. personal qualities that form SPRAM and readiness for research activities and broadening professional knowledge and skills.
5. Purposeful creation of educational situations to include students into social intercourse in the context of future engineering performance. Students from experimental group developed and executed individual and team projects. The subjects of the projects were agreed with industry representatives and had to do with real production tasks. The students made suggestions to improve the existing technological processes at enterprises. To prepare a course project successfully students had to be engaged into real engineering activity, consolidate their knowledge and skills acquired during the studies and develop the components of SPRAM.

4 Research Methodology

Empiric study of SPRAM development was carried out at one of largest National Research Universities in Russia.

The elaborated pedagogical conditions were tested in the course of the experiment to gradually develop the SPRAM of engineering students.

It is known that pedagogical experiment is an organized observation over a definite educational phenomenon in the managed and controlled pedagogical conditions aimed at solving the research tasks.

The experiment was carried out since 2010 till 2015. The population of the study consisted of students of the Institute of Chemical Engineering and Technologies of the Kazan National Research Technological University (KNRTU) majoring in “Material science and materials engineering” and “Chemistry and technology of energy-saturated materials and articles”. Some of them also studied at the Faculty of Additional Education of KNRTU where they took minor degrees in one of the following additional programs: “Psychology”, “Educational Science”, “Company Economics”, “Management”, “Marketing” or “Human Resource Management”.

The sample group included 86 students: control group (40 students) and experimental group (46 students). The model and pedagogical conditions for SPRAM development were systemically implemented at the experimental group while the control group took professional traditional training.

The empiric study consisted of the following stages: summative and formative assessments and evaluation of the test data. Summative assessment was aimed at analyzing the initial level of SPRAM. The following research tools to evaluate the level of SPRAM components were selected: Learning Motivation Survey (version by A.A. Rean, V.A. Yakunin); Motivation to Success Survey (T. Ehlers); Assertiveness Test (V. G. Romek); The Perceived Stress Scale (S. Cohen & G. Williamson); Volitional Potential Test; Communicational and Organizational Skills Survey (COS-2) (V.V. Sinyavskiy, B.A. Fedorishin); and Sociability Level Scale (V.F. Ryakhovskiy). Besides a questionnaire was developed for the experiment purpose to evaluate the students’ knowledge significant for SPRAM development. The students’ academic performance on the disciplines that develop socio-psychological competences was also taken onto account. Research performance of students during their project work was observed, too.

5 Findings of the Study

The results of the ascertaining experiment (summative assessment) showed the homogeneous character of the sample group (Fig. 1 and Table 1).

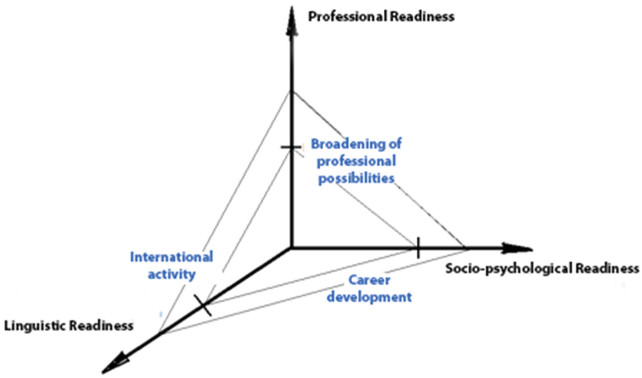

Fig. 1. Three-dimensional model of the future engineers’ readiness for academic mobility

Table 1. Levels of SPRAM development in the control and experimental groups at the beginning of the educational experiment

	Critical	Average	Productive
Control group	42,5	35	22,5
Experimental group	43,5	34,8	21,7

At the formative stage of the educational experiment effectiveness of the projected model and pedagogical conditions for SPRAM development at an engineering university was assessed.

The first pedagogical condition determined the phasing and step-by-step character of the whole process.

To implement the second pedagogical condition it was necessary to develop the engineering students' motivation for planning and participation in the academic mobility programs, and positive emotional attitude towards their academic and professional performance. This task was achieved by purposefully organized pedagogic, consulting, guiding and educational activity of the student groups' curators, mentors and tutors.

The third pedagogical condition allowed using the opportunities of Humanities, aimed at the development of the skills and abilities to plan and to manage educational and professional activity. The implementation of this pedagogical condition based on the Social Sciences and on Humanities, enhanced by programs of additional professional education (minor degree courses) and by the new academic discipline "Psychology of Success". This course was elaborated and introduced into the educational process by the authors. The training package of the discipline was included into the variative part of curriculum (elective courses) at the Institute of Chemical Engineering and Technologies of KNRTU. The mission of the course is as follows: "From individual success to professional excellence" [10]. This main idea determined the specifics of the syllabus composition. The educational material was organized into two sections. The first unit addressed personal traits leading to successful behavior. The second section focused on the psychology of efficient academic and professional performance [11]. The discipline received favorable students' reviews. They pointed out that the course was urgent and necessary for their training and for the future professional activity as well as in their personal lives. The discipline "Psychology of Success" proved to contribute the development of SPRAM of engineering students.

The fourth pedagogical condition provided the needed focus on the personality development during the studies at the majoring department by encouraging the engineering students' research activities and fostering their participation in various individual and team tasks and projects that promote the development of personal qualities that form their SPRAM.

The fifth pedagogical condition was implemented due to task-oriented training situations of being engaged into social interaction in the professional context. The students' generalizing work experience internship and on-the-job training programs at industrial enterprises were the main means to achieve this goal.

At the final stage of the experiment the level of SPRAM of the future engineers was again evaluated using the same research methodology. The findings are presented in Fig. 2 and Table 2.

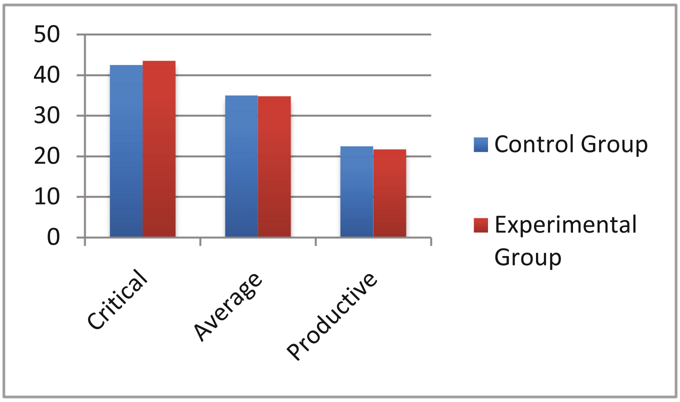

Fig. 2. Levels of SPRAM development at the ascertaining (initial) stage (% of the sample group)

The Fig. 2 and the Table 2 show that 36,9% of experimental group students had productive level of SPRAM and 52,2% of them had average level of SPRAM. Thus the implementation of the suggested pedagogical conditions resulted in increasing of the number of students with productive SPRAM level (+15,2%) and with average SPRAM level (+17,4). In other words 32,6% of engineering students of the experimental group considerably improved their SPRAM while in the control group the number of students with productive SPRAM level at the end of the experiment remained the same as it was at the initial stage. The number of students with average SPRAM level in the control group increased a little (+7,5%) (Fig. 3).

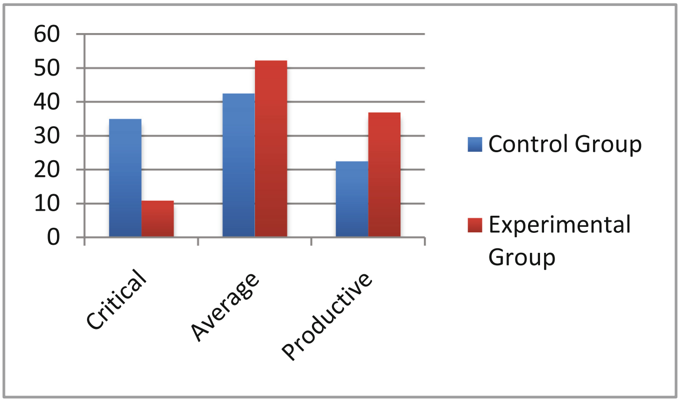

Fig. 3. Levels of SPRAM development at the final stage (% of the sample group)

Table 2. Levels of SPRAM development in the control and experimental groups at the final stage of the educational experiment

	Critical	Average	Productive
Control group	35	42,5	22,5
Experimental group	10,9	52,2	36,9

As a result of introducing all the suggested pedagogical conditions in the experimental group every component of SPRAM of engineering students significantly increased in comparison with the control group were the elaborated pedagogical conditions were not implemented (Table 3).

The findings presented in Table 3 allow concluding that it is appropriate and reasonable to implement the suggested pedagogical conditions in the professional engineering training to develop the future engineers' SPRAM.

Table 3. LEVELS of SPRAM components development in the control (CG) and experimental (EG) groups at the final stage of the educational experiment (%)

SPRAM levels	SPRAM components							
	Motivational		Cognitive		Personality performance		Communicative	
	CG	EG	CG	EG	CG	EG	CG	EG
Critical	27,5	8,7	42,5	13,0	35,0	13,0	35,0	8,8
Average	42,5	43,5	45,0	52,2	45,0	54,4	42,5	39,1
Productive	30,0	47,8	12,5	34,8	20,0	32,6	22,5	39,1

6 Discussion

The study showed that SPRAM of engineering students as a necessary competence of contemporary global engineer may be developed gradually in the course of university studies. The model of progressive SPRAM development was elaborated, theoretically grounded and empirically tested in the context of a National research engineering university. One of the main ideas was to define the top-priority SPRAM component to be developed on every stage and implementation of the revealed pedagogical conditions.

It should be taken into consideration that international academic mobility means more than just the possibility to study abroad. The mutual recognition of diplomas and qualification does not guarantee graduates' competitive ability in the professional sphere. Only professional competence in combination with social skills and psychological characteristics assure a successful career in the global labor market. Furthermore, the most talented employees are the ones with the greatest opportunity to be mobile [6]. Therefore the introduced new author's discipline "Psychology of Success" proved to be a useful tool for developing SPRAM for engineering students.

The course aims to form the concept of success as a phenomenon and to acquire practical skills to develop communication habits and other individual characteristics needful for professional success. “Psychology of Success” is a practically oriented course. The tasks of the course:

- to familiarize the students with various research approaches to success as one of the leading vital personality values;
- to analyze psychological traits which affect personal success positively and negatively;
- to develop time-management skills and habits of putting tasks in priority order to achieve goals efficiently;
- to teach the techniques conflict-management;
- to show necessity and possibility of using the acquired theoretical knowledge in engineering practice, etc.

Every lesson includes discussions, case study and practical recommendations alongside with theoretical material. Seminars and practicums contain self-control tests, psychological testing, and socio-psychological simulation. These interactive educational forms encourage students to analyze the interrelation between personal qualities and professional success [10]. Besides it is important to note that if professional training of future engineers is not combined with social and humanitarian knowledge it may result in contradiction between technological progress and social interests and well-being.

The introduced course is just an example of usefulness of Humanities in the development of SPRAM.

7 Conclusion

Thus SPRAM of engineering students is an integrative personality characteristics that comprise stable motivation, psychological knowledge and skills, self-regulation and self-management mechanisms; desire to apply professional and linguistic skills in the academic and professional engineering practice; ability to build up efficient relationships with other educational process actors, resolve social situations, choose relevant communicational strategies and tactics.

The research revealed a set of pedagogical conditions for the development of SPRAM of students in the engineering university environment and a model of progressive stage-by-stage development of SPRAM that focuse on the social needs for the competent and mobile engineers, on the specifics of educational process in the engineering universities and on the personal ambitions and motivations of the future engineers.

The empiric educational experiment showed that considerable improvement of SPRAM level in the experimental group was a result of a goal-oriented comprehensive pedagogical work, when the suggested model was applied gradually and systemically.

The results of the educational experiment provided evidence for the effectiveness of the suggested model and pedagogical conditions for SPRAM development at the Institute of Chemical Engineering and Technologies of the Kazan National Research Technological University and showed that they may be applied for other engineering majors and (with some adjustment and corrections) for non-engineering universities.

The study does not cover all the aspects of the investigated issue and may serve as a basis for future researches.

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Educational Process at the Technical University Through the Eyes of Its Participants

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Abstract. The active learning principle implies a responsibility of all participants in education process, not only for the training but also for the process of identifying and developing the content, methods and techniques. It is also increasingly demanding of the personal qualities of teachers and trainers. A study was conducted to identify the perceptions and attitudes of three groups participating in the educational process: graduate students, PhD students (intending to become teachers and trainers) and teachers at the Polytechnic University. There were differences in the perceptions of the above groups of what professional and personal qualities of a successful teacher in a technical university should be. The cognitive and functional components of the pedagogical competence are more important for the technical university teachers, whereas the graduate students consider emotional and behavioral components of the pedagogical competence to be more significant. Graduate students and PhD students believe the interactive forms of the educational process to be most effective, whereas the technical university teachers prefer the traditional forms of teaching. The most important professional qualities of a successful technical university teacher include the following: a profound knowledge of the subject, a teachable presentation, an enthusiasm for the subject and the ability to inspire the students for their profession. Such personal qualities as sociability, friendliness, fairness, sense of humor, and sensitivity were the most frequently mentioned ones.

Keywords: Educational process · Organizational forms · Personal and professional qualities of teachers · Students' perception of education

1 Introduction

The importance of Engineering Pedagogy is determined primarily by the significantly changing requirements for modern engineers, the need to improve their competitiveness, versatility and mobility in the global market. New international standards for technical education, implemented in 2000's, are based on the competence approach and aimed to overcome discrepancy between the traditional pedagogy and the modern requirements. The active learning principle implies a responsibility of all the education process participants not only for training but also for the process of identifying and

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developing the content, methods and techniques. It is also increasingly demanding of the personal qualities of teachers and trainers.

This requires a change in the whole system of technical education: content, methods, techniques, forms, training aids etc. A successful implementation in practice of any changes in the education system is possible only with a positive attitude towards them of the educational process direct participants – the teachers and the students. Students are also expected to take part in it. Are they ready for such a change? How do they view their roles and responsibilities? What new qualities would teachers and trainers need to be able to lead the trainees to the desired goals? These are the key questions which initiated this research.

2 Review

Importance of the perception of educational environment by its participants – teachers and students – in the view of its enhancement is well described [1]. Among the most significant factors of educational environment are the features of teaching process including variety of organizational forms, teacher's individuality, curriculum features and management systems [2, 3]. The study of professional and personal qualities of teachers was the focus of many researchers - Kuzmina N.V., Markova A.K, Mitina L. M., Zeer E.F., Kan-Kalik V.A. and others [2, 4]. L.M. Mitina [4] identifies the following characteristics of the personality, affecting the efficiency of the teacher's activities: pedagogical orientation, pedagogical competence and emotional flexibility. Pedagogical competence is regarded not only as a set of knowledge and skills, but also as the ability to defend their own personal position, possession of communicative proficiency, including conflict management capabilities. The emotional flexibility is understood as the optimal combination of emotional expressiveness, responsiveness and emotional stability of the teacher.

Thus, the personal and professional qualities of the teacher are closely intertwined with each other. At the same time, all researchers emphasize a close link between the development of the personality of the teacher and an effective professional activity of the teacher, calling it a "supra-professional" component, stressing the need to develop not only cognitive and behavioral qualities, but also a definitely emotionally-sensual sphere. This is especially important for the higher education system, including technical education, because the quality of an active interaction of the teacher with the student is reflected in the efficiency of learning.

V.K. Dyachenko [5] believed that this communication makes a material basis for the learning process. Of particular importance in this case is that the organization of such a dialogue is also a form of organization of educational process. Under the organizational form of learning we understand the form, or the process of the interaction of students with the teacher, of students with each other and of new students with those who have already studied the material, carried out in a certain mode [3]. In the socio-cultural context of learning it is seen as a form of pedagogical system, requiring interaction between the participants of the educational process (direct and indirect), aimed at addressing specific learning objectives.

Interaction during training can be based on the 5 organizational forms of learning [5]. According to V.K. Dyachenko, each organizational form may have its own methods and techniques of the organization of such an interaction (communication) of the participants of the learning process. These five organizational forms are:

1. **Individual.** Independent work with sources of information: reading and writing (notes, annotating, various types of essays, reports on practice, term papers, research papers), work with audio and video information, problem solving, work on PC etc.
2. **Pairs.** Communication with another person for obtaining new information: tutoring, teacher-student interaction, consultation with a research advisor, test or exam, discussions with a peer student etc.
3. **Group.** One talks while the others are listening: lessons, lectures (including different types and methods of activation), practical training, communication in small groups, laboratory work, excursions, electives etc.
4. **Collective.** Communication in changing pairs with its variety of techniques:

   – Method of additions (text and image)
   – Technique monitors (text and image)
   – Methods of studying complex texts (A. Rivin)
   – Method of routings
   – "Opinion poll"
   – Technique of mutual simulation of training system (Mkrtchan M.A.)
   – Work with the new theoretical material through sharing it (V.K. Dyachenko).

5. **Collective-Dynamic.** Communication in changing groups: small group communication, open space, collective games (business modeling, managerial, etc.). This type of arranging the learning process enables a dialogue between each and every participant, sharing the information available, acquisition of new information and learning it in the process of mutual teaching, specific validation of learning outcomes. Thus the collective training combines the principles of personalization of learning with general cooperation [6–8].

3 The Study

3.1 Objectives

The objective of this study is to identify the subjective perceptions of students and teachers of the personal and professional qualities, which, in their opinion, an effective teacher at the technical university should have; as well as the current and ideal representation of the forms of organization of the educational process. To answer these questions we conducted a study of perceptions and attitudes of three groups of participants of the educational process: graduate students, PhD students (going to become teachers and trainers) and teachers at the Polytechnic University. The study sets out the following tasks:

(1) To explore the perceptions and attitudes of the above three groups regarding the personal and professional qualities of a successful contemporary technical university teacher.
(2) To explore the perceptions and attitudes of the above three groups regarding the effective forms of the educational process at the technical university.
(3) Compare the perceptions and attitudes of the above three groups regarding the educational process at the technical university.

For the purposes of the study we identified two components in the structure of the educational process – the personal and professional qualities of the teachers, and the forms of arranging the educational process. In our opinion, these components are among the key ones in achieving the goals of the educational process, and are also more accessible for identifying and analyzing for the members of the study group.

3.2 Methods

The following research methods and techniques were used: observations, structured interviews, guided discussions, questionnaires, documents reviews, qualitative statistical analysis, developing an inventory to identify the perceptions of personal and professional qualities of a successful (qualified) technical university teacher, developing an inventory to identify the concepts of the effective organizational forms of training at the technical university:

1. At stage 1 a pilot study was conducted that included Questionnaire 1, consisting of two open questions: What are the professional qualities of an effective teacher at a modern technical university? What personal qualities are necessary to be an effective teacher at a modern technical university? 10 most frequently provided descriptions of professional and personal qualities were identified. Questionnaire 2 was developed based on this data.
2. Questionnaire 2 was designed to identify the most significant personal and professional qualities of an effective teacher at the technical university. The questionnaire includes two questions. The respondents had to rank 10 personal and 10 professional qualities (identified on the basis of the pilot study): 1 – for the most significant quality, and 10 – for the least significant one.
3. Questionnaire 3 was developed for the study of representations of the real and the ideal distribution of time between different organizational forms of training at the technical university. Respondents were asked to rate the share, which methods and techniques of different organizational forms of learning have in their practice. They had to distribute: (a) 100% of real training time between the given organizational forms (see above classification of organizational forms); (b) 100% of ideal training time, based on their perceptions of how much time should be given to communication between the participants of the educational process in each of the organizational forms of training in the educational process ("University of the Future").

3.3 Participants

In the selection of respondents according to the purposes of the study the aim was to represent three groups of participants of the educational process: graduate students, PhD students (going to become teachers and trainers) and teachers of technical disciplines at the Polytechnic University with total number of participants – 361.

3.4 Data Acquisition

The research consisted of conducting interviews and presenting inventories in two stages:

Stage 1 (November–January 2015) - pilot study, which involved 75 students and 86 graduate students.
Stage 2 (March–April 2016) - basic research of the educational process at the technical university, which involved 80 graduate students, 80 PhD students and 40 teachers.

4 Interpreting the Data

4.1 The Pilot Study to Identify the Shortlist of the Personal and Professional Qualities of the Teachers

During the pilot study the students and the PhD students selected 10 most desired professional and personal qualities of an effective teacher at the technical university. The list of the most frequently selected items is represented in the Table 1:

In general, the lists of these qualities coincide for the graduate and PhD students. Students pay more attention to quality-related pedagogical orientation, personal

Table 1. The most frequently selected professional and personal qualities of an effective teacher of technical university

Professional qualities of teachers (rating)	Personal qualities of teachers (rating)
Knowledge of the subject	Communicability
Clarity of presentation	Charisma
Enthusiasm	Fairness
Ability to inspire students	Sense of humor
Work experience	Goodwill
Individual approach to students	Kindness responsiveness
Practical orientation of teaching	Mutual understanding with students
Interest in the result	Punctuality
Innovation	Openness
Erudition	Impartiality

approach to students, interest in the result, practice-oriented teaching. PhD students are being prepared or have already started a professional teaching career and therefore value its components (Erudition, Knowledge of the subject, Innovation), the students also appreciate higher the qualities that have a greater influence on the effectiveness of their teaching, contribute to their motivation and success in training. The personal qualities lists made by the students rank higher the qualities, directly related to the communication with them (Understanding, Fairness, Sense of humor, Openness). These qualities were used as the basis of profiles for the main study.

4.2 Summary Results of the Ranking of Professional Qualities of an Effective Teacher at the Technical University

The results show (Fig. 1) that for all three groups, the knowledge of the subject is the most important parameter, this is especially characteristic for the teachers (average grade 2.13):

Also important for the effective teacher is, according to the responses, the clarity of presentation, ability to arouse enthusiasm for the subject and interest in the result. A reliably significant difference was obtained for the following data: the least significant (for all three groups) were such qualities as innovation and erudition; a lower rank (which indicates a greater importance of the quality) the students, in comparison with the post-graduate students and teachers, gave to the individual approach, work experience. Less important for students, as compared with the other two groups, is being interested in the results.

For teachers the most significant features (compared to other groups) were being interested in the results of the training, while the individual approach was less important. However, in general the consensus in the distribution of professional qualities of an effective teacher should be noted. This is, primarily, a person who knows the subject and is able to explain it clearly to the students, who is interested in the subject, and who has a traditional approach to the educational process at the university.

The features that were less important for students include: innovation, knowledge, interest in the results and experience; while the ability to arouse interest, the knowledge of the subject, the clarity of presentation are more important.

Knowledge-oriented education model prevails in the participants' perception of the educational process, as opposed to the person-centered model of education, which is still being implemented. It can be noted that students may have a passive-utilitarian attitude to the educational process.

For the PhD students the most important professional skills include: the knowledge of the subject, clarity, the ability to arouse interest; and the least important ones are: the individual approach, experience, erudition. The teachers' data are actually identical to those of the PhD students.

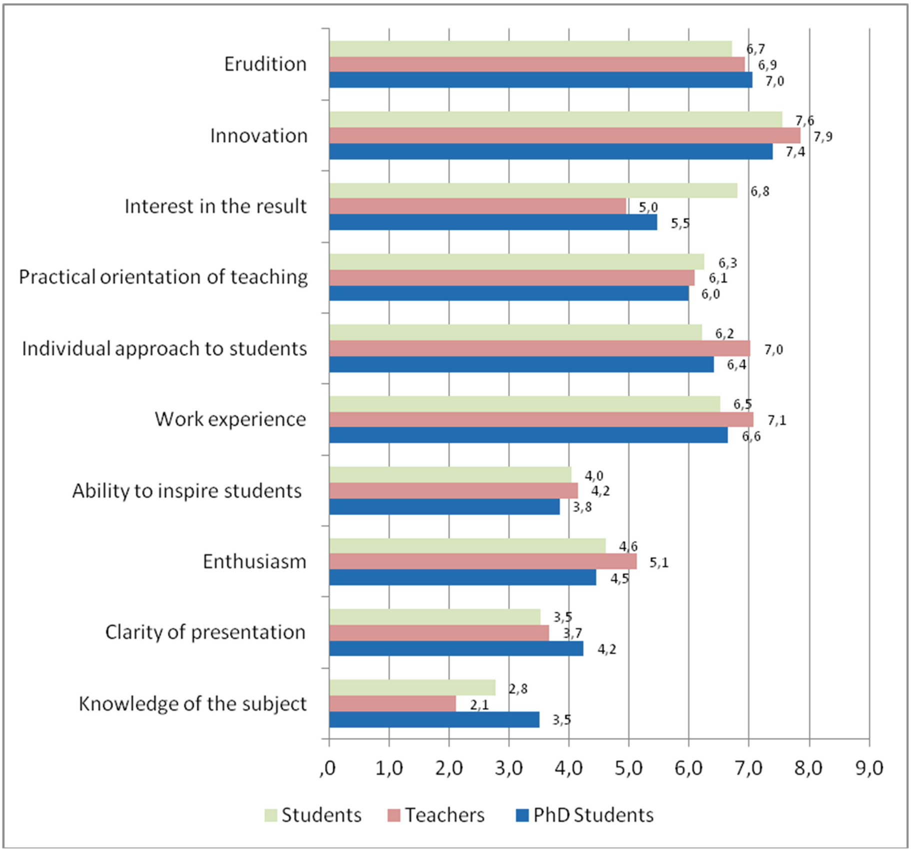

Fig. 1. Summary ranking of professional qualities of an effective technical university teacher

4.3 Summary Ranking of Personal Qualities of an Effective Teacher at the Technical University

Ranking of the personal qualities shows a greater range of opinions, both within the groups and between them (Fig. 2). So for the students the most important personal qualities are justice (however, the average rank is 4), rapport with students (4.65), fairness (5.25). The lower rank, in comparison with other groups (statistically significant difference) has the sense of humor, while communicability earned a higher rank. Punctuality, openness and responsiveness are the least important features for the students.

For the PhD students the most significant qualities are the rapport with students, communicability and fairness. Less important are punctuality (statistically significant difference), sense of humor, kindness.

For the teachers the most significant qualities are: justice, mutual understanding with students, communicability. The least significant qualities are openness, sense of humor, responsiveness (statistically significant difference). The PhD students and the teachers,

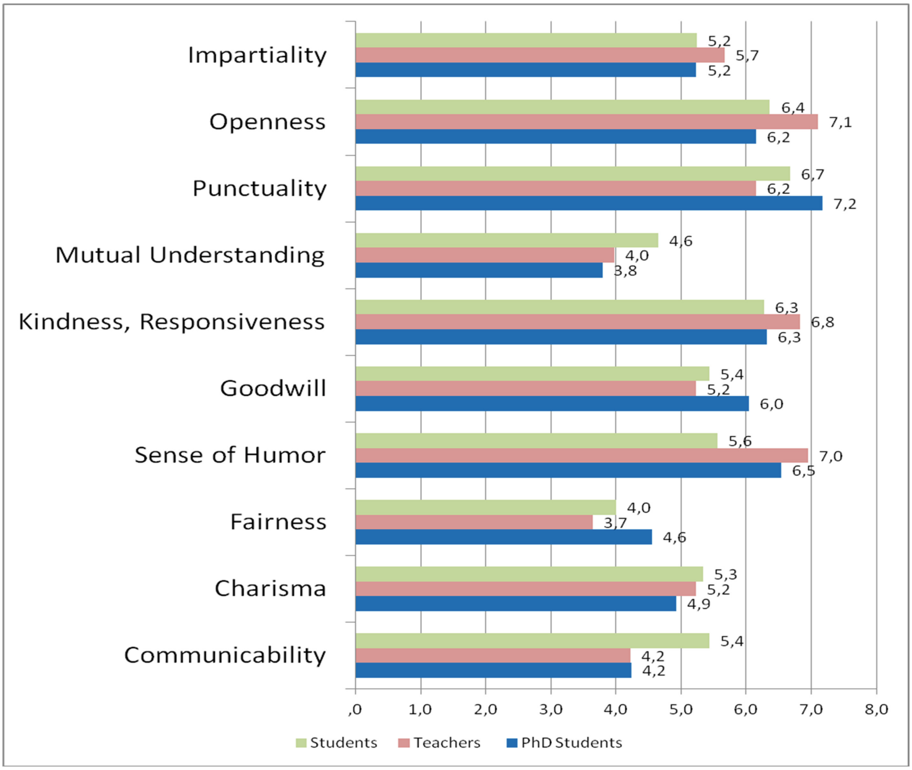

Fig. 2. Summary ranking of personal qualities of an effective technical university teacher

despite the choosing communicability as one of the most important qualities, believe that an effective teacher must be sufficiently discreet in the communication process, should not be demonstrating the personal attitude to the subject, or to the students.

For the students the important qualities are fairness, understanding and communicability. They are worried about the lack of objectivity in the assessment process, the subjective evaluation. Insignificant for the students are: openness, punctuality. The students value the sense of humor higher than the others do. The teachers gave a higher rank to fairness, than the students.

The PhD students demonstrated evaluations very similar with those by the students. The main issues for them are the understanding, charisma and justice. They need the teacher as a friend, to a greater degree.

The teachers appreciate punctuality more than the PhD and other students. Openness for them is not important, because it can be risky for them. For the teachers the "Ideal" teacher is fair, communicative and charismatic. The traditional system of attitudes is passed down from generation to generation. The wish to change the educational process is not associated with a change in themselves, their position. Hierarchical and individual forms are valued higher than the collective and network ones. Personal communication skills are attractive, but the forms that develop these qualities are not a priority.

There is a difference in the perceptions of the graduate students, the PhD students and the teachers of what professional and personal qualities of a successful teacher at the technical university should be. The cognitive and functional components of the pedagogical competence would be more important for the technical university teachers, whereas the graduate students consider the emotional and behavioral components of pedagogical competence to be more significant. The PhD students stand in between of these two groups.

4.4 Distribution of Teaching Time Among the Organizational Forms

The study of the distribution of teaching time between the organizational forms in percentages according to the survey of teachers and PhD students presented on the Fig. 3.

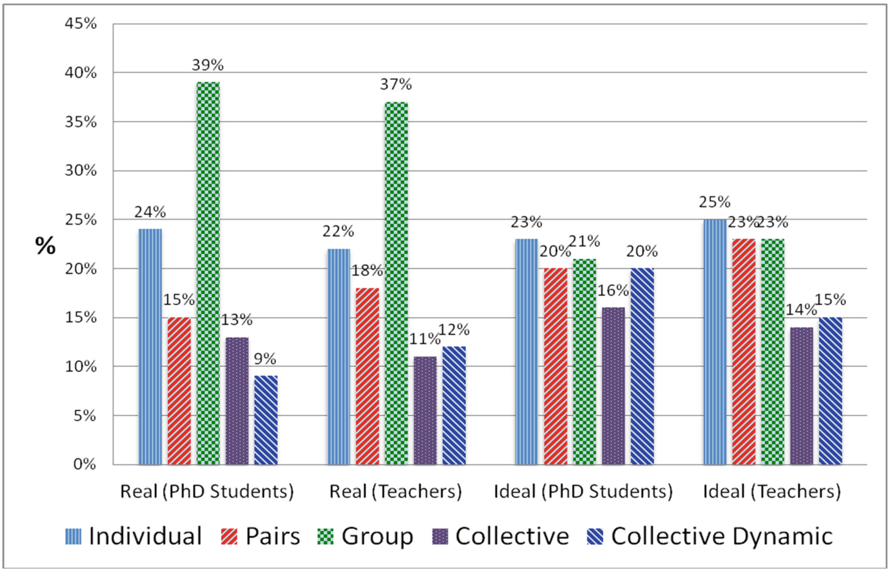

Fig. 3. Distribution of teaching time among the organizational forms: Real and Ideal evaluation by the teachers and the PhD students.

It shows that, in general, both the teachers, and the graduate students realize the need to reduce the proportion of actual time in the educational process used for the Group work (presentation in front of the group) and increasing the share of other forms of communication - Individual, in Pairs and Collective learning activities, which can be seen from the difference between the real and the ideal, in their opinion, training time shares.

The graduate students and the PhD students consider interactive forms of organization of the educational process to be most effective, whereas the technical university teachers prefer the traditional forms of teaching.

The conclusion regarding the group form based on the opinion of the teachers and the graduate students, as well as on our experience, is that the group methods are dominant in teaching. Both groups state that, ideally, there should be less of it. The least represented are the Collective and the Collective dynamic forms. Both groups believe that they should be more prominent. The Pair work form is actually less presented; ideally it should be used more. The teachers see the future mostly in the individual, advisory work with students.

5 Results

The most important professional qualities of a successful technical university teacher include: the knowledge of the subject, clear presentation, enthusiasm for the subject and the ability to inspire the students for their profession. Among the most often mentioned personal qualities are sociability, friendliness, fairness, sense of humor, sensitivity.

The results of the research show that the teachers and the PhD students assess the distribution of the different forms of organization in the educational process at the technical university very similarly. Participants of the educational process perceive the Group organizational form as the dominant one - 40%, followed by the Individual (independent work of students) - about 23%, the Collective (interactive) form - about 22%, and the last place belongs to the work in Pairs - about 15%. No reliably significant difference between perceptions of those two groups was identified.

It is important to note that the PhD students and the teachers see the future of the educational process in reducing the share of the Group organizational form as less suitable for the modern requirements of technical training. The PhD students suggest reducing the training time dedicated to this form almost by half, while increasing the time for Collective and Pair work forms. The educational process must become more individualized, active, enabling all the participants to get involved in the development of new knowledge, sharing personal resources, which implies a "subject-subject" (inter-personal) position of the participants in the educational process. The relative share of the time for the independent work of students should be reduced.

The responses of the teachers, in general, demonstrated the same trend: a decrease of the Group, Pairs and Collective forms in ideal educational situation. The teachers are more cautious in perceiving possible changes in the educational process at the technical university. Recognizing the need for the introduction of "subject-subject" relations in the educational process (the use of student-centered educational paradigm), they see the possibility of such changes in the use of already existing traditional organizational forms (Individual and Pairs).

6 Conclusion

Based on the results of the study the following conclusions can be drawn from the obtained data:

1. In assessing the professional qualities of the ideal effective teacher the students more value enthusiasm, knowledge of the subject, clarity of presentation more and less value innovation, erudition, interest in the results, or work experience. The PhD students and the teachers appreciate knowledge of the subject, clarity of presentation, ability to inspire students more, and do not give significant values to the individual approach, work experience or erudition. It appears that in the view of the participants the traditional knowledge-oriented education model is prevalent in the educational process. Personality-oriented model is poorly represented. It might be realized in the passive-utilitarian approach of the students to the educational process.
2. The list of the personal qualities of the effective teachers is approximately the same in the groups of the students and the PhD students: fairness, mutual understanding and communicability. More valued was the teacher's sense of humor. Low values were given to openness and punctuality. Teachers more value punctuality, fairness, communicability and charisma. To a lesser degree they value openness, which, apparently, can be considered as risky. These data representing a subjective students' perception indirectly point to the individual approach importance for them. Both groups of students seem to need a teacher as a friend who would always help and support them.
3. Both the teachers and the students evaluate the distribution of time between different organizational forms in a very similar way. Most of them are "captivated" by the traditional "subject-object" (teacher centered) interaction concepts of the educational process and, even being aware of the need for change, see it more in the terms of cosmetic correction, but not in a radical restructuring based on the subject-subject pedagogical interaction approach.
4. In general, it can be noted that the traditional system of attitudes regarding the organizational forms distribution is passed down from generation to generation. The need for change in the educational process is not usually associated with the change of attitudes and preferences in the educational activities. Hierarchical and individual forms are still valued higher than the collective and networking forms. The personal communication skills are important and attractive, but the educational forms that develop these qualities are not a priority in the teaching practice.
5. The study of the educational process at the technical university through the eyes of its participants highlighted some contradictions and coordination within three groups of participants: graduate students (being currently taught), PhD students (being currently taught and preparing to teach) and acting teachers. The goal of implementing modern educational standards and active learning approach needs more coordination and mutual understanding in developing contemporary forms of teaching and personal qualities of successful teachers and trainers. Involving students in the design of the educational process will help to make them more interested and be able to take control of their own learning experience.

It is expected that a larger-scale study of perceptions, thoughts and attitudes of all participants of the educational process at the technical university will reveal the hidden contradictions of the educational process and provide material for further research in order to modify the educational process through the coordination of the participants' expectations and professional requirements. It will also help to establish a better continuing education of the teachers and the PhD students who receive teacher training and prepare to work in the field of the higher education in the future.

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Learning Engineering Through Teams

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Abstract. Certainly apprehensive with how things go in academia concerning engineering project education we observed and analysed different learning settings, either in engineering schools and companies, by discussing with different actors (academic community, teachers, pedagogical and scientific board elements, students). We exercised some alternative approaches to distinct learning paradigms, and we concluded for simple general recommendations that can be placed in practice in academia and companies, in engineering project contexts. The goal of our research is to make explicit a specific paradigm, an integrated way of looking into engineering practice and engineering learning, mainly in engineering projects context. Internalizing lessons from this alternative paradigm we deploy a way of doing in class that can be explored as active learning and project-based learning. The main advantage of our proposed approach is that learning occurs by doing and, we would say more importantly, learning occurs almost as a sub-product of doing. And in fact there are mix goals in our approach. One is performing, and obtaining results in engineering project design and development, the second one is a by-product and it is learning, enriching its own dynamic capabilities, and internalizing tacit and explicit knowledge about the work experienced. Of course the effectiveness of this model resides in the alignment of the two goals, which implies mature stuff and mature students almost about taking their master degree.

Keywords: Engineering education · Team work · Problematization · Problem solving · Network of actors and value networks · Project-based learning

1 Introduction

The engineer is a structural actor in society, and can assume and explore many different roles. He develops processes, technologies, constructs new realities, controls achievements, and measures and evaluates how technical artefacts and technical systems are performing and being done. He is concerned with quality, robustness of technological things, sustainability and alignment of solutions, all concepts that are systemic and global. He creates and develops, designs and constructs, and he his master of design, a system thinker. In fact, engineering was born completely devoted to technology, to create technology, to make it work, to take advantage of it within situated contexts, contributing to create organizational and social value. But engineering basic principles (deeply founded in science, deduction and quantitative reasoning) [21] tends to stay the same as technology quickly changes. Social habits change. People and organizational

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cultures change. Besides, all of us increased our technological dependence, almost everything we do is powered by technology, and technology is no more subjected to the same rules of 30, or even 20 years ago. In the last few year's context and other different variables evolved in the engineering process, things changed, business models changed, materiality was challenged, complexity changed and, we can say, everything changed at the same time. Singular changes and the cumulative result of changes completely altered engineering context and engineering content, disrupting the engineering act as it used to be for decades, maybe centuries. Social habits transferred action from reality to marketspace, from looking *in the eyes* to the powerful idea of imagining and acting remotely in virtual contexts. Communications and operational processing capacity improved in unimaginable ways definitely defying Moore's law.

In fact everything related with technology and engineering practice became more difficult and demanding, taking place in contexts millions of times more competitive, where the quantity of variables in play and the possible interconnections between these variables exploded. That means complexity. Complexity exploded not because we are constructing more complex artefacts, but because everything changed, and links between different things blasted. Pressures on time commitments, shortage on development cycles, all these represent constrains with which engineering must deal in order to be effective and ensure quality. Plan for change and change plans during project's execution are crucial operations to survive. In this situation two facts are beginning to be clearly understood and generally indisputable, engineers alone are no longer viable. Engineering practice need collaborative teams [23] with different expertise, sometimes with different sensibilities, and cultures. Engineer's expertise is no longer enough, technology and social are intertwined [10] and the engineer needs to, apart from technical proficiency, develop a social mind. Only equipped with these hybrid lenses (the ones from technology knowledge and the others from the social understanding, both integrated together) can the engineer understand his own role in the engineering practice process.

So, if technology is changing, if the ways in which people relate with technology is changing, can engineering schools rest the same? Should we anticipate changes in engineering education methods and approaches? Can an engineering education system based on problem solving persist? Can the divorce from social sciences be admitted in engineering design? Are engineering problems well defined? Does context play a role in technology design and development, and planning?

We could deploy many questions alike, pointing to different aspects and fragilities of our typical and most representative learning paradigms, but this is not our goal with this paper, and we will progress our main line. Context of the engineering act, the way engineering practice is situated, these are details of paramount importance, reason why we turn to this issue in our next section.

2 Context

The engineer, the person, the individual, the actor itself, used to be a lonely runner. Not anymore, nowadays the engineer is complied to work within a team, not only because of the increasing specialization of action but also because action is taken in complex systems and complex environments, where change occurs systematically and new problems emerge. I remember a very successful physician in Portugal saying that he doesn't practice surgery (liver surgery) in private hospitals, even when patients ask him very obstinately. And he doesn't because to practice surgery he needs to work with his own team, with the different specialized doctors, a well-aligned team used to work together able to assist any possible emergent problem. A team like this can be addressed as a network of value. The value of this actor network comes from the different ways actors can link to each other, how the role of each actor can change and adapt, performing brilliantly a common goal. That is what happens with engineering practice, with problems emerging from the practice itself, from the changing links with environment, engineering practice need to be prepared and able to adjust to changing necessities, always pursuing a validated goal.

Also, as technology provides a service and is adopted by organizations and society, the boundaries of technological systems blur and expand, integrating different needs, touching people with different mindsets, specializations, and cultures. So, due to this specialization-distributed-systemic facet of technologic artefacts and technological systems, teamwork is essential [19]. The engineer, an educated professional, needs to learn how to deal with people around, people of different technological backgrounds, and even people with no technological background at all. That is why the engineer needs to understand the social, the networks of sociotechnical actors that participate in the processes, expressed in needs, wants, habits, preferences, cultures, laws, regulations and policies.

In a similar approach, engineering as a discipline also works in partnership, trying to aggregate and integrate different knowledge areas. It is increasingly necessary to understand this integration, necessary to design and develop the systems in hand. A systemic view and not only the view of parts are becoming fundamental to ensure that the right problem is solved in an effective manner.

Some decades ago, in the fifties in the United States, in a meeting of the best engineering schools, social science was considered to be mandatory in the engineering curricula.

"In professional engineering practice the "new situation" often involves social and economic as well as technical elements, and these are not entirely separable. Thus the end result is not merely the numerical solution of a technical problem but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form…", Grinter report (1955).

The National Society of Professional Engineers [26] considers three basic or foundational capabilities: One is mathematics, other is natural sciences, and the thirds are humanities and social sciences.

In fact there are intrinsic connections of engineering and physics and mathematics, and they are undisputable, but the fundamental connections of engineering with social sciences need yet to be conquered. These sociotechnical connections are even more important when we envisage systems, their boundaries and environment, inherent aspects of the engineering act [12]. Unfortunately, in general, the incursion into social sciences is considered to be merely decorative. It is not important per se, only considered as general culture. And that is unacceptable. As we try to demonstrate.

The fact is that to work within teams of people alike or of completely different people is becoming mandatory. The real value of what is being designed and developed needs to be commonly understood and accepted, becoming a common ontology. This teamwork is not only concerned with performing tasks, it is also concerned with sociotechnical processes like decision taking about what to do, and how to do, who will be affected by doing, and so on. These sociotechnical processes' are also a base for problematization, that means a negotiation and common acceptance (alignment) of what is the problem to be solved, its context, and the interdependencies with other systems, viability, and value added, necessary to implement solutions, quality and sustainable solutions.

3 Action Due

Considering the ill-defined structure of real engineering problems we must recognize that the usual positivist paradigm ruling in engineering schools – namely problem solving and deductive confirmation of hypothesis – is not the most fruitful. This becomes more problematic when we see this same paradigm to be dominant in the engineering field of research. A significant part of the research production is based on the deployment of hypothesis that needs to be validated, and the effort of validating them. The research is focused on validating these hypotheses and we recall the interesting questioning of Karl Popper with his theory of refutation. But returning to the problem solving detail, why are engineer students being given well-defined problems with well-defined data sets and why are they trained to apply basically the fundaments (physics and mathematics) to solve this class of problems? Two errors in the same take!

If we ask why this is like that, we can only receive an answer, because things have always been like that! In fact we would risk saying that the most important in approaching engineering problems is what we referred as the problematization, the way we define the problem and the negotiations and coalitions we need to arrange and construct stable solutions to this problem. This means dealing with the problem itself and all the settings that envelops the problem, and these require social abilities, soft skills, and group work. More than that, problems need to be designed according to different variables, technical variables but also social variables, in real life contexts, with real life needs and restrictions. And these real problems need to be negotiated and constructed with different stakeholders. Align complex sets of different variables and technology within a same goal is only one of the topics in this context [1, 8, 20]. In a similar perspective Donald Schön referred to problem setting and Michel Callon referred to actor-networks, detours, translations, and alignment.

Prospect engineers (I mean engineering students) need to learn how to grab data, what data is relevant to grab and what is not, how to identify stakeholders, how to negotiate with them in order to construct requirements and specifications, how to design a specific feasible and well defined scope, how to access the value of the thing under design, what there is to do and what there is not, what is the value of the solutions to be implemented and their sustainability. We should keep in mind that we are looking for sustainable solutions. In this process we stress that the engineer need to hear and understand clients and users, but this is an active process because it implies provocative and disruptive translations in order to help the client or user in defining what they really want and need, and what is possible, what is not, and what would be the value of developing such a thing [3]. Sometimes (we could say most part of the times) the client doesn't know very well what he wants. In engineering design and development the logic of value needs to be explored in a wider range then just economic results and achievements. We need to address the utility and value added of what we are doing from different actor's point of view, and these different points of view need to conciliate [15].

The formulation of the problem, the problematization, is one of the most significant and noble moments of the engineering design act. Quality aspects begin at the moment we define and construct what we are going to do and what is the problem we are going to tackle and solve. And we need to understand that we are always acting in a context of scarce resources, meaning work availability, financial availability, infrastructure reliability, and knowledge readiness [14, 15]. Social and organizational scope management has to be designed with all these variables in a systemic approach of convenient proportions [6].

In fact engineering practice is becoming, more and more, a network of different actors (stakeholders), with different sensibilities. Engineering practice is becoming more and more a social practice performed in heterogeneous teams.

Considering what was stated, why are engineering schools insisting in training engineer's students in problem solving only? We risk having good solvers of wrong problems! That is a waist of resources, quality and effectiveness. We know engineers learn with the market, with action, by doing, but why are they not better prepared in their own engineering schools?

We are not saying that problem solving is not a fundamental approach, we are just saying that insisting in this limitative procedure lacks effectiveness, doesn't ensure quality and is not adapted to real life, and real problems. This traditional and wrong approach is limiting the value of engineering practice [5]. To confirm what is said we can address the work of [7, 13, 16, 22] as we could refer many others, but we can also consult statistics of project success. Worldwide these statistics [11, 18, 23], wherever they come from show an embarrassing level of failure, with high rates of projects cancelled and running under specifications (either in cost, time, or scope, usually with cumulative problems in all the referred dimensions).

We can argue, but engineering cannot continue like this? Maybe yes, it always has been like that, so it is probably sustainable, but changes are welcome. And are these changes possible? We think they are not only possible but also mandatory [4].

4 A Case Study on Engineering Learning

Due to different opportunities and different stakeholder interests we were involved in a learning experience that went quite well. This experience went on designing a semester course in an engineering and management of energy master in IST, Lisbon. IST is the biggest and oldest engineering school in Portugal. The course was "Project" and should be taken immediately before the thesis, most part of the times with some overlap with this thesis. With these details we intend to say that students are at their best in terms of maturity and they are already caring about readiness to market. With these elements in mind we searched for a company that was interested in presenting students real problems hoping they can deliver interesting solutions to the company. This company was EDP the biggest utility in Portugal, the fourth largest wind operator in the world, and the EDP sub companies involved were EDP renewable (EDPR), and EDP Innovation (EDPI). As we already noticed when stressing value extending away from only profit, the value of this approach for the company was manifold and not at all economical, or commercial. Pointing out new ideas, new approaches, new technologies and exploring new business models in the wind energy sector was the main purpose of the experience. We had sixteen students that were divided in four groups of four students each.

Specifying further, the main goal of this experience was to pressure students to develop and create competences on a specific real problem. Particularly students needed to choose and define evaluate and try to convince a company to undertake a new investment on the wind energy sector. The challenge was to investigate the value of implementing condition monitoring systems for the assets of EDPR, wind energy farms.

Students were challenged to research by their own on the value of specifically planned monitoring systems for the assets of EDPR, discussing the different types of systems and evaluating the cost saving opportunities and value positioning face to face to the state-of-the-art systems currently on the market.

We explored a roll-play were we defined gate meetings to discuss and evaluate progress. So, after a kick-off meeting of about three hours where we defined the rules, the goals, what we expect from the groups, how we (stuff) would be available for doubts and help, we scheduled five gate (control, facilitating, discussing) meetings. After kick-off, two weeks later, was Gate 1, three weeks later Gate 2, three weeks later Gate 3, two weeks later Gate 4 and finally three weeks later Gate 5, the final one. Apart from group presentations in each gate (all the elements of the group take part), there were questions and answers from the company representative (that were the owners of the case study), IST stuff and all students involved, of all the groups. This discussion always took the time considered necessary, with no particular time restrictions. In average and apart from Gate 5, which was longer, these sessions took about two hours, two and a half. Gate 5 was the final one, it needed to recollect details from other phases and presentations and discussions took more time, something like four and half, five hours, for the four groups involved.

This experience proved to be good for all involved, students, company and school (IST). Bounded by some help, students were obliged to work by themselves, learning by doing, with their own assumptions and decisions. They even choose what to do and how to do it. So Gate 1 was basically a general literature review on technology and business models already applied in wind energy plants (farms), the different aspects that could drive improvements, different ways of exploring, policies and rules to respect, different players, and so on. In this phase or step, groups were suggested to cooperate between each other, for instance providing fair divisions of scope in order to have an interesting Gate 1 and not a repetitive one. Apart from this initial gate groups were always advised to cooperate. With this model we are not only providing cooperation within groups, but we were also advising and promoting cooperation between competing groups (they compete on the mark they will achieve in the semester).

There is no sound new experience till the moment, but we already tackled with problems not well defined, formulation of the problem to solve, ambiguity concerning different paths and lines of action, possibility to assume reasonable things (educated guessing is a very good friend of engineers) [17], collaboration not only within a group, but inter-groups.

Gate 2 was mainly focused to conquer a licence to invest on the research of a specific approach, mainly a technology, selecting specific problematic and addressing requirements for a potential implementation. This licence means the company supports what the group is intending to do.

Gate 3 was concerned with the economics. A sound cost/benefit analysis was the main driver to sustain the selected approach. Using different scenarios, opportunity cost, and many alternative possibilities, different approaches were explored, instigated and analysed.

Gate 4 was concerned with design and development of the approach (engineering, technology, social factors, economic viability, opportunity), paying specific attention to what already exists, competition and feasibility of the proposed solutions as well as to be or not to be aligned with the company (client) strategies.

Gate 5 was concerned with presenting an end-to-end solution, stressing the objective of convincing the investor to buy that specific solution. Final presentations of all groups were more complete, including details from the other phases and trying to be assertive. With this presentation a final report is issued completely according to the academic rules, that is with an abstract that explains what the group did and how, an introduction contextualizing and defining the problem, a good development of the problematic, a sound conclusion, and well-addressed academic references.

At the end of Gate 5 each group already presented an average of two hours of PowerPoint, followed by tuff discussion of approximately the same duration. This discussion was mainly oriented to viability, technological and economical viability, value to the company, and willingness to pursuit with a solution based in the explored concept. This discussion was always oriented to improvement of ideas, concepts, artefacts, models, and approaches, and it was always conducted in a learning oriented way.

All performances were rated. The groups, being in wide competition, were always advised to cooperate. Step-by-step along the life cycle of the project all groups were valued, all presentations and discussions rated (quality of presentation, quality of content, quality of data), and at the end groups were ranked.

5 Summary and Possibilities for Further Research

Using a flexible network of value with actors in different domains, always with a content that is crucial to engineering approaches, we explore how to make better decisions, how to undertake problem setting and solving under a project management approach, adjusting quality and ethics, perceiving a sense of value (social, economic, sociotechnical, organizational, project), visiting best practices in management. In this loose setting engineers student's gain a different conscience of the engineering act, and the engineering act itself expands, including sensibilities of the social. In fact, exploring the basic concept of identifying all actors (stakeholders) involved as actors in a network, having the sense that nothing can be taken for granted as action depends on negotiations among the different actors, and problems and constrains emerge continually, engineer student's gain a different sense of mission that positively affects the way they think, behave, design and decide their actions. This approach to the engineering act tends to strongly link the situated problem (framed purpose of the project) with the context, to understand technology as a sociotechnical thing, defining a network of different interests, where values are permanently negotiated and renegotiated and action attends emergence of phenomena.

The engineer that leads and positions in the top of a professional pyramid and the other one that is leaded and has a more operational duty, they both gain in their sense of team aligned with an organizational purpose. They both gain with an expanded territory where technology cohabits with social concerns and values are integrated, conceptualised in situated time-spaces. This conscience is also a base for sustainability. Sustainability that needs to be positioned as core in the process of creating new things, of developing new technology and eventually controlling its use. Society, economy, environment, sustainability all are influenced by technology and technology development, so the engineer needs to develop and integrated mind to approach systems as extended systems.

And these abilities are not crucial because engineers tend to become managers, as some people tend to say, but in order to practice a better engineering. In fact, as neuroscientists [2] clearly stated, the mechanistic approach stated by the Descartes legacy [9] is no longer the best approach to deal with complex systems. Engineering needs to enlarge its duties, the engineer needs to become more like a man in full, more versatile and with and extended conscience of things.

With this experience we tried to improve engineering students global maturity, not only because they were obliged to define their own way in pursuing their goal, but also because we made them internalize that technology itself is nothing. Technology only means something in a specific context of use. Technology serves organizations and social demands and needs to be validated trough economic, ethic, and sustainable values. Technology is something the new engineer needs to integrate in a system of values. Providing a loose space to exert these values was the main advantage of this experience.

We tried to tackle these problems and reflect on the changing value of engineering practices, aligning some educative strategies. These educative strategies per se and trying to convince people of the importance of this subject were the main goals of this article.

The ideas presented in this article are not altogether rocket new, no, they explore concepts sometimes well known and already discussed. The eventual advantage of this article is to contribute to the internalization of some of the concepts. In fact they are known, they are considered very important but nobody cares and things just go on as usual. I always remember a personal story to explain the difference between knowing and being able to apply. Some twenty years ago I read about counter steering in motorcycles, in a book by Keith Code [24, 25]. Being an experienced motorcyclist I was suspicious. Basically counter steering is about the behaviour of the system (motorcycle, bicycle, at speeds upper then 20 km/h) when turning, stating that the artefact turns in the opposite direction of the pressure you exert in the handlebars. In fact, after experiencing the trick it took me almost two years to completely dominate the technique. This elapsed time was not the time of knowing, or understanding, it was the time of internalizing, the time necessary to be able to apply the technique in full, almost without thinking. With this simple story we try to explain that discover something is not an end, but on the contrary the beginning of a reflexion cycle that tends to improve with time, experience and reasoning.

Finally, the experience of working with the client (not to but with) is also a very important approach in the learning mind-set of students. In the referred networks of actors that in our metaphor translate the engineering act, the client is always a very important partner. If engineers can work with him instead of for him the change is huge and results would be significant. That was also a message we tried to translate with our teaching/learning experience.

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Entrepreneurship in Engineering Education

Modular Curriculum and Practical Evaluation of the Model

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Abstract. The idea to divide the curriculum for entrepreneurial education in modules, leads to the advantage that the programme consists of four modules and they can treated as separate subjects. Breaking away from the traditional teaching methods, the pedagogical tools get more and more interactive, self-learning and experimental. The didactic approach divides the content elements in three categories: (i) face-to-face instructions, (ii) independent learning and (iii) practical learning. The approach of active learning results in technicians, which are aware of the entrepreneurial spirit. They are fit to do all the economic and innovative engineering steps to evolve the product idea to a real, merchantable product. Through evaluation the success of the curriculum is verified and the basic element for quality assurance and further development.

Keywords: Entrepreneurship · Engineering education · Product innovation · Idea development

1 Introduction

The programme applies an active learning strategy, introducing theories and reaching conclusions through experience with real life situations, followed by analysis and reflection. Students should actively participate in the learning process prepared to take responsibility for their individual learning

In addition to applying the principles of the social constructivist learning approach, entrepreneurship studies are also well suited for project learning, which supports the construction of a new knowledge in a social environment, in cooperation with other students. Project based learning also promotes the development of teamwork and time management skills, as well as the group-element in setting and fulfilling goals, which internally promotes contribution from all participants in the process.

Another point is that any model needs the connection to the real world, which means the evaluation process and the practical results. Therefore a test was involved, for measuring the effect of the training modulus in Entrepreneurship for Engineers [1].

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2 Methodologies for Theories in Teaching

The programme applies an active learning strategy, introducing theories and reaching conclusions through experience with real life situations, followed by analysis and reflection. Students should actively participate in the learning process prepared to take responsibility for their individual learning

In addition to applying the principles of the social constructivist learning approach, entrepreneurship studies are also well suited for project learning, which supports the construction of a new knowledge in a social environment, in cooperation with other students. Project based learning also promotes the development of teamwork and time management skills, as well as the group-element in setting and fulfilling goals, which internally promotes contribution from all participants in the process.

The main aspects for success can be summarised as follows:

- Activating the student`s prior experiences
- Application of meta-cognitive and self-management skills
- Negotiations, sharing perceptions, discussions and learning in teams
- Problem solving and constructing skills
- Authentic or simulated learning environment
- The teacher has a supportive role in the learning process as opposed to being a transmitter of knowledge
- Assessment supports development of metacognitive skills and a better self-awareness
- Acquirement of certificates

2.1 Social Constructivist Learning Process

At the start of the course it is very important that the students reflect to their prior knowledge by writing, trough discussion or by keeping a study diary. In the case of the methods, there should be a wide range to keep the students concentrated in the learning process. Following list gives an overview, but for sure, is not containing all existing tools:

- Monitoring of personal strengths and weaknesses
- Inter-group peer assessments
- Assessment of teamwork (distribution of roles, time management)
- Solving of business related problems through role playing games (negotiations with a potential investor)
- Team collect information on business (analysis of failures and successes)
- Team generates ideas for a business plan (for products or services)
- Finding real investment possibilities
- Communication and marketing analysis of real life situations
- Feedback sessions in small groups
- Reciprocal assessment within group and between groups

2.2 Project Based Learning

The principles of project based learning show interesting characteristics. Learning takes place in groups. The students complete a concrete and broad scoped assignment, or solve real life problems. The participation of the students is active, constructive and independent in planning, implementing and assessing projects. The tasks completed in the course of the project demand cooperation, negotiation and teaching agreements. The students organize and evaluate their work by themselves. The project must have a concrete material or conceptual goal.

3 Curriculum Modules

The pedagogic conception of entrepreneurship studies for engineering students is based on the four modules:

- personal development:

The goal is to support the student's personal development in terms of improving self-awareness, raising efficiency as well as mapping a personal career-plan.

- from idea to innovation:

Applying creative problem solving assignments, which are drawn from real live situations.

- public relations and media:

This subject aims to give an overview of different types of media, the nature of public relations, communication with the press and creating a business image.

- executing an idea – business plan:

Shaping entrepreneurial skills, knowledge and attitudes, application in the specialized area of business.

3.1 Personal Development

The aim is to support the students in terms of improving self- awareness, setting goals and creating a foundation for life long learning shaping an enterprising attitude.

3.2 Idea to Innovation

The business idea is clearly worded and is based on the form of a prototype. The innovative business idea must be must be presented to potential customers in the form of a prototype.

3.3 Public Relations and Media

Using the business ideas generated in the previous module, students devise an image and create an identity for the business. The product/service, accompanied with a critical devised identity and brand, is advertised in social media to reach and attract as many potential consumers as possible.

3.4 Business Plan

A successful financial forecast presumes a strong market analysis, which requires an iterative, analytical approach for all parts of the business plan.

4 Curriculum Application

The effectiveness of raising awareness of business is not immediately clear, instead emerging over a long period, measurable by a number of new business or successful new businesses. In order to gain some insight on the impact that the curriculum will have on its subjects, a survey of the business modules follows, assessing the entrepreneurial attitudes of the participants. A survey taken at the beginning of the studies provides initial assessments of participants and can be used to determine individualized emphasis. The third measurement measures the consolidated result and determines whether individual modules of stud need to be changed.

A lot of different models are reported in the literature about measuring the entrepreneurial attitudes. Following In this investigation the model described in the project “Entrepreneurship, attitudes and personality traits” should be taken into account [2]. Regarding the model, three factors are known, to be important parameter in entrepreneurial readiness.

Those three factors are innovation, self-esteem and self-confidence. Highly innovative people do not follow rules or behavioral patterns as strictly, which means they tend to have a bigger playing field for solving tasks and problems. They do not necessarily follow the orthodox guidelines or behavior, if there is no use in doing so. Self-esteem is the perception of oneself and one’s abilities. Individuals with a high potential for this characteristic are convinced that they can actively influence the direction of matters with their abilities and competence. They attribute their success and failures primarily to their own behavior, not externalities or others. They often work independently and take responsibility upon themselves, and will not readily let others stand in for them. Individuals with high self-confidence believe they are able to get things done and actively influence their environment. They have a positive outlook on themselves and their abilities. They are prepared to take on challenges with the necessary self-confidence and hope to rely on their own competency in difficult situations.

On basis of the test students find out their entrepreneurial attitude. The Teachers or study supervisors should emphasise before testing that there are no right or wrong answers and that the survey is most effective when answers are honest.

The test measures the three fields based on a point system, each score is compared with a standard value, and the result is always a relative value. A short sample of the survey should demonstrate what the students will be asked:

- I have always tried to be the best.
- I don’t feel that I am a complete failure when my endeavours do not go as planned.

- I create opportunities for myself and take advantage of these.
- I feel great because I know that at the end I am responsible for my own success.
- In ambiguous situations, I usually take responsibility upon myself.

The model refers to the following five indicators for the personality analysis (Extroversion, Emotional stability, Assertiveness, Tolerance of insecurity and Result-orientation) and three indicators for the entrepreneurial mindset model (Innovativeness, Visible self-confidence and visible self-esteem).

5 Analysis of the Results

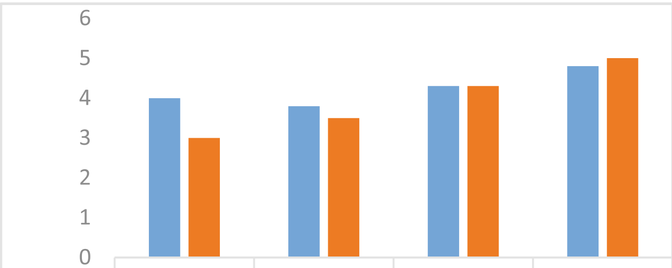
In order to ensure quality [3] in the entrepreneurship education a survey system was developed for retrieving feedback on the effectiveness of the work done with participants and elicit opinions on the content of the curriculum. The survey as we mentioned before, includes several parts, categorized according to personality traits and entrepreneurial attitudes. The personality traits portion is not examined in the following comparison; the focus is on the project's score, the attitudes toward entrepreneurship.

The reason for the first test was to get information about the general sense of different perceptions, and there just one question was asked: How interested would you be in starting a business in the future?

The following diagram in Fig. 1. shows the results before and after the program content was communicated. There is first of all an influence correlating to the age of the participants. The group of the age between 18 and 20 has a lower tendency to start a business and the value is even decreasing after the program.

It seems that they lose self-confidence, after getting the information what can happen with young start up companies.

In general, we can conclude that, based on the maximum value of five, the indicators are very high, and the desire to start a business increases with the increasing age of the participants.



	18-20	21-25	26-30	31-
prior	4	3.8	4.3	4.8
after	3	3.5	4.3	5

Fig. 1. Entrepreneur attitude prior and after training and in relation to the age of the participants

Fig. 2. Change in attitude to entrepreneurship due to entrepreneurship studies

The following comparison shows the results in the three important indicators of business: innovativeness, self-confidence and self-esteem (Fig. 2).

While the impact of studies on the first two indicators is negligible, a more significant rise could be observed in the case of self-esteem. We assume this is a very important result and shows the positive effect of training entrepreneurship basics.

6 Conclusion

The study and comparison demonstrate a certain impact to the entrepreneurship behavior of students and that is confirmed by experience. Indeed, the 18–25 old participants are interested in the course contents and business, but they prefer to start their own business later, when they have increased their practical experience.

It is evident that the evaluation and presentation of some of the data shows the complexity of the topic and offers abundant opportunities for discussions, which could be performed with participants and other interested entrepreneurs.

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Analysis of STEM Teaching – Most Common Strategies and Methods Enabling Deep Understanding and Interactive Learning Applied by Graduates of Technical Teacher Initial and Continuing Education Programs in Estonia

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Abstract. The purpose of this paper is to introduce and analyze results of the research carried out at Estonian Centre for Engineering Pedagogy at Tallinn University of Technology (TUT). Micro-lessons of 260 technical teachers teaching at vocational schools, gymnasiums and universities have been analyzed with special matrix for lesson analysis. The research has been carried out in 4 groups: (1) STEM teaching at vocational schools, (2) STEM teaching at gymnasiums (high schools), (3) STEM teaching at universities (including colleges and universities of applied higher education), and (4) STEM continuing education in engineering companies. Most common teaching models, strategies and methods enabling deep understanding and interactive learning used in STEM teaching by technical teachers who have graduated from TUT either on master level or in continuing education have been determined and analyzed in the present article.

Keywords: STEM · Teaching strategies · Teaching methods

1 Introduction

STEM programs are designed to integrate science, technology, engineering, and mathematics in the classroom with the aim to teach students to think critically and have engineering or design approach towards real-world problems while building on their math and science base [1].

What separates STEM from the traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. Effective provision of STEM requires a foundation of strong subject matter teaching. STEM approach requires a greater degree of collaboration across the whole institution in planning and delivery of STEM activities.

According to Crawley, et al. [2] the purpose of engineering education is to provide the learning required by students to become successful engineers or knowledge workers – technical expertise, social awareness and knowledge of innovation. The combined set of

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knowledge, skills and attitudes is essential to strengthening productivity, entrepreneurship and excellence in the environment being based on technologically complex and sustainable products, processes and systems. Accordingly we improve the quality and nature of engineering education. Thus the objective of engineering education is to educate students who are ready to engineer, deeply knowledgeable of technical fundamentals.

Technical teachers have to be competent in the relevant field of engineering and subject they teach. But they also need to know how to teach effectively, the core knowledge is to know in-action how to do it in real-life situations and for real professional purposes. The purpose of this paper is to determine and introduce the most common teaching strategies and methods enabling deep understanding and interactive learning in teaching STEM used by technical teachers who have graduated from TUT either on master level or in continuing education.

2 Technical Teacher Education at TUT

Knowledge of a variety of instructional strategies and methods, and flexibility to change them within and among lessons are two of greatest assets a technical teacher can have. A teacher should be able to select a proper instructional strategy for a specific learning outcome.

The design of learner-centered program for initial and continuing education of technical teachers has been launched at Estonian Centre for Engineering Pedagogy at TUT since 2006. The aim of the design has been the structured program facilitating the teaching experience, thus educating effective technical teachers, and teaching the art of teaching.

Technical teacher education in TUT is based on TUT model of flexible teacher education (Fig. 1). The central idea of the model is the IGIP curriculum [3] in the minimal amount of 20 ECTS. IGIP curriculum serves as the basis of the following curricula at TUT:

- master curriculum for technical teachers (120 ECTS);
- the curriculum of continuing education for technical teachers (25 ECTS);
- the curriculum of continuing education for teaching staff (faculty) of TUT (25 ECTS);
- the curriculum of additional specialty of a technical teacher for the students of TUT learning on bachelor, master and doctoral level (45 ECTS);
- the curriculum of additional specialty of a technical teacher for engineers (25 ECTS).

The program is also suitable for university staff teaching in the field of STEM (science, technology, engineering and mathematics), being also crucial for improving the quality of teaching in the relevant field. Usually university professors are highly qualified in the field they teach, but they lack the knowledge of how to teach their subjects more effectively, taking account of students' differences and different learning styles.

The emphasis of the design of the program has been on teaching of applied knowledge to technical teachers, including the principles of the choice of content, methodology, motivation, creativity, reflection and problem-solving, choice of

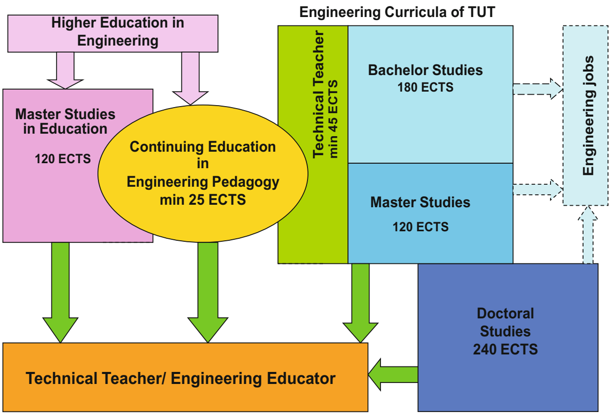

Fig. 1. The model of flexible technical teacher education at TUT

technology, effective teaching methods, models and strategies – concepts, tools and procedures of the field of STEM, organized in ways enabling teachers to formulate problems and solve them and teach engineering effectively.

As the required entrance qualification of candidates is at least Master degree in engineering (or STEM), it is assumed that they have already acquired a complete knowledge and practical skills in the relevant field of engineering on high level afore. Engineers acquire additionally contemporary knowledge and skills in teaching engineering subjects, both in theory and practice.

The main common subjects of the different paths of the model have been presented in Table 1.

Table 1. Structure of the common subjects of the curricula of the model of flexible technical teacher education at TUT

Modules	ECTS Credits
Compulsory subjects	
Engineering pedagogy in theory and practice	6
Laboratory didactics	2
Psychological and sociological aspects	3
Ethical aspects and intercultural competencies	1
Rhetoric, communication and scientific writing	3
Working with projects: curriculum design and analysis	3
IT in teaching engineering	3
Multicultural learning environment	1
Elective subjects (3 ECTS)	
Portfolio assessment	1
Creative and critical thinking	1
Coaching and mentoring	1
Team-based and problem-based learning	1
Total	**25**

Effective contemporary strategies and models have been used for teaching creativity, critical thinking skills and capitalizing deep understanding in teaching engineering. Contemporary teaching methods, emphasizing conceptual understanding, adapted specially for engineering education have been widely tested at Estonian Centre for Engineering Pedagogy (TUT) and switched into described study programs [6].

Education is completed after the final examination held by a commission of at least 3 members. Prerequisite of the final examination is timely submission of a teaching portfolio. The final examination consists of the written and oral examination. On the oral examination students must present an interactive micro-lesson, there is also discussion of the results of a written examination in Engineering Pedagogy Science and an examination interview about the portfolio's components.

The portfolio should contain the complete written planning and performance of teaching sessions, compiled teaching materials, used teaching methods, assessment methods, models and strategies, analysis on the teaching and students' learning styles, feedback, and a subsequent self-analysis. The activity of a future teacher during the presentation of the interactive micro-lesson is monitored and registered according to the special protocol of engineering pedagogy. Precise criteria and requirements for holding the micro-lesson have been compiled and introduced to the students.

The designed and analyzed programs are the only ones in Estonia, providing technical teacher education on master level or in continuing education. The programs have been registered by Estonian Ministry of Education and Research and accredited by International Society for Engineering Education (IGIP).

Technical teachers have to teach students to ask questions and think critically, define and solve open-ended problems which can be learned by practicing. Thus students assume more responsibility and are better motivated, becoming successful lifelong learners and better practitioners in their future teaching profession. Indirect teaching encourages students to analyze, critique, judge, compare, contrast, evaluate, assess, create, predict, apply, use, implement and gain professional perfection [4].

3 Methodology and Results of the Research

The aim of the present research was to determine and analyze the most commonly used teaching strategies and methods in STEM teaching at vocational schools, gymnasiums (high schools) and universities.

Quantitative method (survey) has been used in the research. The research sample (N = 260) has been compiled of technical teachers and engineering educators who have passed master studies and continuing education for technical teachers at TUT, and teach STEM subjects on different educational levels.

136 teachers (52% of the sample) had passed master studies for technical teachers at TUT, and 124 teachers (48% of the sample) had graduated from the courses of continuing education for technical teachers at Estonian Centre for Engineering Pedagogy at TUT. The average age of teachers in the sample was 32 years, 48% were female and 52% male teachers. 78 teachers teach STEM courses at the university level at Tallinn University of Technology, 71 teachers teach STEM at gymnasiums, 102 teachers teach STEM at

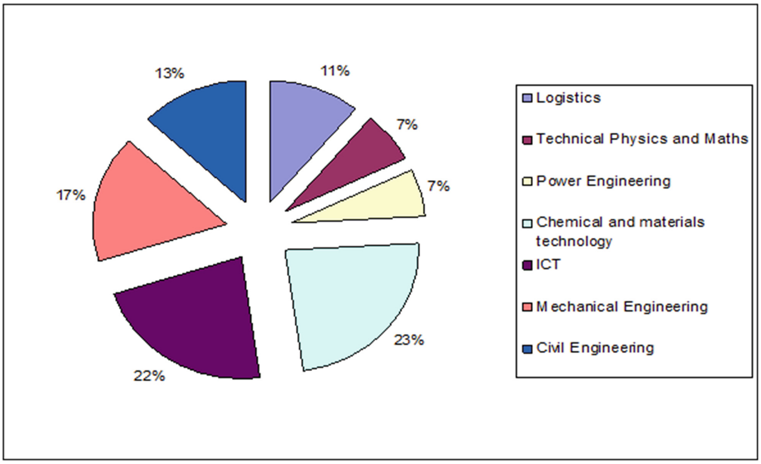

Fig. 2. Specialty of STEM teachers participating in the research

vocational schools, and 9 serve as training specialists at engineering companies. The specialty of the teachers in the sample has been presented in Fig. 2.

Micro-lessons of 260 technical teachers have been analyzed at final examinations of teacher education at TUT. A special evaluation matrix has been designed for STEM lesson analysis. Most commonly used teaching models, methods and strategies have been determined in the research. Results have been analyzed and systematized in four groups: teaching strategies used in teaching STEM at (1) vocational schools, (2) gymnasiums, (3) universities, and (4) engineering companies.

Teaching models used in micro-lessons by STEM teachers have been presented in Table 2. As it could be seen the most commonly used teaching models have been indirect, direct teaching, and less preferred was integrated teaching model.

Table 2. Teaching models used in micro-lessons by STEM teachers

Models Used in Teaching STEM	Frequency of the Use of Teaching Models			
	Vocational Schools	Gymnasiums	Universities	Companies
Indirect teaching	59	31	51	4
Direct teaching	31	25	21	4
Integrated teaching	12	15	6	1

Vocational teachers have most frequently used indirect (frequency 59), direct teaching models (31), and integrated model (12). Technical teachers at gymnasiums have also preferred indirect (31), direct teaching model (25), and integrated model (15). Technical teachers at universities have preferred indirect teaching (51) and direct teaching (21), and indirect teaching model (6). Teaching specialists from engineering companies have preferred indirect teaching model (4), direct (4) and integrated teaching model (1).

The Most preferred teaching methods in teaching STEM at micro-lessons have been presented in Table 3. As it could be seen, vocational teachers have preferred interactive lectures with active breaks (frequency 33), laboratories and case-studies (12), classical lectures (10) and problem-based learning (PBL) (9).

Gymnasium STEM teachers prefer classical lectures (18), interactive lectures with active breaks (15). STEM teachers at universities have preferred laboratories (18), classical lectures (17), interactive lectures (16) and PBL (11). Teaching specialists at engineering companies have preferred interactive lectures the most (4).

Table 3. Teaching methods used in teaching STEM at micro-lessons

Methods used in teaching STEM	Frequency of the use of teaching methods			
	Vocational schools	Gymnasiums	Universities	Companies
Interactive lectures	33	15	16	4
Classical lectures	10	18	17	1
Seminars	6	4	5	1
Laboratories	12	4	18	0
Virtual, remote & e-labs	1	1	2	0
Problem-based learning	9	6	11	0
Project-based learning	1	5	6	0
Team-based learning	3	2	4	1
Inquiry-based learning	1	1	2	0
e-learning	1	1	3	1
Blended learning	5	2	4	0
Flipped classroom	8	3	2	0
Case studies	12	5	3	1
Just-in-time teaching	9	4	1	0

The most preferable teaching strategies in teaching STEM have been presented in Table 4. As it could be seen, the most preferred strategy of vocational STEM teachers have been active learning (18) and questioning (14). Gymnasium STEM teachers preferred active learning (21), questioning (15) and collaborative/cooperative learning (14). Most frequently used teaching strategies by university teachers have been active learning (21), questioning (15) and collaborative/cooperative learning (14). Training specialists of engineering companied have preferred active learning (4) and questioning (3).

Table 4. Teaching strategies used in teaching STEM in micro-lessons

Strategies used in teaching STEM	Frequency of Strategies Used			
	Vocational schools	Gymnasium	Universities	Companies
Questioning	14	15	11	3
Active learning	18	21	22	4
Collaborative/cooperative learning	12	14	16	1
Demonstrations	5	7	2	0
Experiential learning	2	3	4	1
Portfolio	3	1	5	0
Online/hybrid courses	1	1	2	0
Interdisciplinary teaching	5	8	4	0
Learning videos	6	3	3	1
Critical thinking	7	11	17	2
Concept maps	2	4	2	0
Feedback	8	9	11	1
Service learning	12	0	0	2
Peer assessment	6	5	7	0
Simulations & games	2	4	2	0
Problem solving	6	9	12	0
Clickers	0	0	0	0
Discussions	9	9	11	3
Social media	6	8	2	0

4 Discussion

Engineering educators should gain greater confidence through the use of extended range of contemporary teaching tools by obtaining specifics of the art of teaching.

Expert teachers generally are comfortable with wide range of teaching strategies, varying them skillfully according to the learning task and learners' needs. Some of these are general strategies, such as skilled questioning, clear communication, organizing lessons, and effective feedback, starting lessons with a review and ending with closure, applicable in all teaching situations [5]. Other, more explicit strategies, called teaching models, are grounded in learning and motivation theory and designed to reach specific learning objectives [6]. All of them are designed to help students develop a deep understanding of the topics they study and improve their critical thinking abilities [7].

According to the results of the present research 56% of technical teachers preferred indirect teaching model, 31% preferred direct teaching model and 13% preferred integrated teaching model. If analyzed according to different school types, it may be concluded, that 58% of technical teachers working at vocational schools preferred indirect teaching model, 30% direct model and 12% integrated model. 44% of technical teachers working at gymnasiums (high schools) preferred indirect teaching model, 35% preferred direct model and 21% preferred integrated model. 65% of technical teachers working at universities preferred indirect teaching model, 27% preferred direct model and 8% preferred integrated model. 44% of technical teachers working as training specialists at engineering companies preferred direct model, 44% preferred indirect model and 12% preferred integrated model (see Table 2). It may be concluded that more than half of technical teachers prefer indirect teaching model in teaching STEM.

Indirect instruction is an approach to teaching and learning in which concepts, pat-terns and abstractions are taught in the context of strategies that emphasize concept learning, inquiry learning and problem-centered learning. Instead of beginning with general principles and eventually getting to applications, engineering educator begins with specifics – a set of observations or experimental data to interpret, or a complex real-world problem to solve. As the students attempt to analyze the data or scenario or solve the problem, they generate a need for facts, rules, procedures, and guiding principles, at which point they are either presented with the needed information or helped to discover it for themselves [7]. It is based on constructional learning principles [8].

Direct instruction is based on behavioral learning principles (obtaining students′ attention, reinforcing correct responses, providing corrective feedback, and practicing correct responses). Students learn basic skills more rapidly when they receive a greater portion of their instruction directly from the teacher, thus gaining systematic knowledge and abstract thinking [9, 10].

According to the present research the most popular teaching method have been interactive lectures (26%), followed by classical lectures (18%), laboratories (13%), problem-based learning (10%), case studies (8%), seminars (6%), project-based learning, just-in-time teaching and flipped classrooms (all 5%), team-based learning and blended learning (both 4%), e-learning (3%) and e-labs (2%). 32% of technical teachers teaching at vocational schools preferred interactive lectures, 10% prefer case studies and classical lectures. 25% of gymnasiums teachers preferred classical lectures and 21% interactive lectures. 23% of university teachers preferred laboratory lessons, 22% classical lectures, 21% interactive lectures, 14% preferred problem-based learning. 44% of teaching specialists at engineering companies preferred interactive lectures (Table 3).

University teachers preferred interactive and classical lectures, laboratory lessons and problem-based learning. Gymnasium teachers preferred classical lectures to interactive lectures. Vocational teachers preferred interactive lectures, laboratory lessons and case studies (Table 3). Majority of preferred teaching methods described above are relevant to indirect teaching model.

According to the present research the most preferred instructional strategies have been strategies of indirect teaching: active learning (preferred by 25% of technical teachers), followed by questioning and collaborative/cooperative learning (both 17%), critical thinking (14%), discussions (12%), feedback (11%), problem solving (19%), peer assessment and interdisciplinary teaching (both 7%), demonstrations (5%), experiential learning (4%) (Table 4). 18% of technical teachers working at vocational schools preferred active leaning, 14% preferred questioning, 12% preferred service learning and collaborative/cooperative learning. 30% of gymnasium STEM teachers preferred active learning, 21% preferred questioning, 20% collaborative/cooperative learning, and 15% critical thinking. 22% of technical teachers teaching at universities preferred active learning, 22% critical learning, 21% cooperative/collaborative learning, 15% problem solving, and 14% preferred questioning, feedback and discussions. 44% of teaching specialists working at companies preferred active learning, 33% questioning, and 22% preferred critical thinking. Active learning, collaborative/cooperative learning and critical thinking have been the most popular teaching strategies among university and gymnasium teachers. Vocational teachers preferred active and service learning. All strategies described above facilitate indirect teaching and constructional learning environment.

Teaching for higher-order outcomes requires instructional strategies that represent the indirect instruction [10]. Instructional strategies of *indirect model* are instructional approaches that start with and unknown principle and then attention moves to a known one. A teacher using an indirect approach may start a lesson with asking questions and using examples and thus helping students to recognize the principle being learned. This approach is very effective because students interact with the content to make meaning. Indirect approach often begins with exploratory activities and lead to students discovering a concept or generalization.

Indirect teaching methods suitable for teaching engineering (project-based, problem-based learning, and "just-in-time" teaching) are taught in the teaching process of the master program and continuing education for technical teachers at Estonian Centre for Engineering Pedagogy.

In *problem-based learning* students are confronted with an open-ended, real-world problem and work in teams to identify learning needs and develop a viable solution, with instructors acting as facilitators rather than primary sources of information thus engaging the students in the types of reflection and activities that lead to higher-order learning [11].

Project-based learning begins with an assignment to carry out one or more tasks that lead to the production of the final product – a design, a model, a device or a computer simulation and is very suitable for engineering education. The culmination of the project is normally a written report summarizing the procedure used to produce the product and presenting the outcome [12].

Just-in-time teaching [10] combines Web-based technology with active learning methods in the classroom. Students individually complete Web-based assignments before class, the instructor reads through their answers before class and adjusts the lessons accordingly ("just in time"). Just-in-time teaching classes are a combination of interactive lectures and laboratories.

Through indirect teaching students assume more responsibility and are better motivated, becoming successful lifelong learners and better practitioners in their future teaching profession. Indirect teaching encourages students to analyze, critique, judge, compare, contrast, evaluate, assess, create, predict, apply, use, implement and gain professional perfection.

5 Conclusions

Technical teachers are usually highly qualified in the field they work in but they often lack education in the teaching profession. A highly specialized person often concentrates on the topic not taking account of the basic rules and principles necessary to be applied in all phases of the educational process. If so, it influences the quality of students' knowledge.

Quality of engineering education crucially depends on the quality of teaching. In order to improve the quality of engineering education, the foremost mission should be the improvement of the quality of education of engineering educators. Without improving the education of educators we cannot bring about any positive changes in the overall educational system. Engineering educators need a fundamental academic engineering education, professional experience and a comprehensive teaching training.

Through indirect teaching model, methods and strategies students assume more responsibility and are better motivated, becoming successful lifelong learners and better practitioners in their future teaching profession.

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A Self-Reflection on the Importance of Project Activities in Engineering Education

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Abstract. In this paper, the author elaborates about several examples of the multidisciplinary projects on which he was involved throughout his five years as Integrated Master's student in Mechanical Engineering at the Faculty of Engineering of University of Porto. This self-reflection aims to explain how these projects contributed to enrich, not only his technological and scientific knowledge, but also on how they have influenced his methodology as a student and how it lead to the research environment. The author would like to highlight that the multidisciplinarity of the course fed his motivation to learn and allowed him to established multiple connections between different topics such as mechanics, informatics and electronics.

Keywords: Multidisciplinary projects · Project learning activities · Self-reflection process · Engineering education

1 Introduction

The author graduated from the Faculty of Engineering of University of Porto (FEUP) with a Master's degree in Mechanical Engineering. With the changes in Higher Education under the Bologna process, the Integrated Master course has a duration of five years. The author attended his cycle of studies between the academic years 2009/10 and 2013/14. The Integrated Master in Mechanical Engineering at FEUP has the EUR-ACE Quality Label since 2008, with the last accreditation being valid for a 6 year period, until 2022 [1], guaranteeing that the course meets European and international standards and is recognised throughout Europe.

The Mechanical Engineering course is a very comprehensive one, approaching many subjects throughout the various fields of study. Some project-based learning approaches are offered at FEUP either as a component of some curricular course for all students or as a voluntary component for the most proactive students [2]. The possibility of being involved in multidisciplinary projects throughout the whole course gives the student a better perception of the integration of knowledge and the connections between subjects [3]. The experiences of team work as a student and an even closer connection to research team elements during the final year are enforced by the learning methodologies used

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in FEUP. Those approaches encouraged the author to join that specific research group after graduation.

The author also underlines that engaging in research discussion, group meetings and reviewing the state of the art and looking for new solutions has expanded his reasoning, creativity and interest in knowledge and in learning new subjects with many different backgrounds.

In the next section, the author describes some of the most relevant multidisciplinary projects and experiences during his path as a student, referring their main goals and the most important aspects that contributed positively, and how the introduction to research and development activities (R&D) increased the author's involvement, accountability level, interest, creativity and encouragement in development innovation that lead to his academic success and later involvement in R&D activities.

2 Mechanical Engineering Student

University of Porto, namely its Faculty of Engineering, defend the important role of new teaching and learning methodologies and initiatives to promote engineering education within the high education and training of future engineers [2]. Concerning those new teaching and learning methodologies, FEUP strongly encourage the promoting of students skills through group work, cooperation with others, interdisciplinary projects, and that mindset is transmitted to students since the first year as an engineering student. Despite the author having interest in all of them, only the most relevant projects and the ones that contributed the most for his growth are described on the next sections.

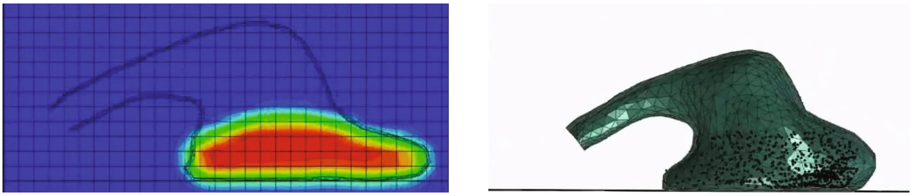
2.1 Numeric Simulations and Structural Mechanics

In the academic year 2011/12 the author had the opportunity to conduct an optional assignment under the Structural Mechanics course. In addition to using the Finite Elements Method (FEM) applied to solving numeric analysis of elastic linear structures under the course's common teaching methods and learning activities, the author was able to simulate coupled fluid - structure interactions applied to Biomechanics.

The numeric study consisted in simulating the interaction of a bladder model filled with fluid from 300 mm height under two different approaches: the Coupled Eulerian-Lagrangian method (CEL) and the Smoothed-Particle Hydrodynamics method (SPH) under ABAQUS. Figure 1 shows the results comparison between the methods used [4].

This work allowed a more in-depth study related to the FEM and on numerical methods with an emphasis on computational mechanics in general. Also, it contributed to better understand the relevance of using numerical methods applied to real problems in Biomechanics and in the study of the human body.

These activities motivated further research on numeric methods during 2012 under the formerly know IDMEC, an interface research institute at FEUP.



(a) Coupled Eulerian-Langrangian (b) Smoothed-Particle Hydrodynamics

Fig. 1. Comparison between coupled fluid-structure numerical simulations using CEL and SPH methods

This research activity consisted in a preliminary study of an alternative method for numeric analysis called Isogeometric Analysis (IGA). This alternative method was recent at that time and has proven to be an alternative to the already established FEM method, being able achieve similar results with less computational time involved. These research activities lead the author to write his first article, still as a student, using IGA to simulate the structural behaviour of a human bone (femur) under a static load, which he had the opportunity to present at the 5th Portuguese Congress on Biomechanics [5]. The involvement within a research field while still being a student gave the author the concept of individual responsibility as a member of a team and was also a great opportunity to have a first contact with research groups and to understand his role as a member of a team, as well as the role of a research group within scientific community.

3 Final Year as an Automation Student

In the academic year 2013/14 the author engaged his final year as an Integrated Master's Degree in Mechanical Engineering student, having chosen the Automation branch. On the first semester, the author had some Automation related courses which were followed by his master thesis.

3.1 Industrial Computing

This Industrial Computing course had a wide comprehensiveness of topics that were lectured during the theoretical classes and the students had the possibility to select one of those for a group project. Also, the formal teaching of microcontrollers was introduced into this course on that year. The author choose a final assessment group project within the microcontrollers theme, the DC motor control [6].

This work required the group of students to build a electronic circuit based on Microchip microcontrollers in order to be able to control the angular velocity of a DC motor. Figure 2 depicts the final setup used for this group project [7].

In order to implement different control algorithms, the group used the Quadrature Encoder Interface (QEI) module from the microcontroller to get

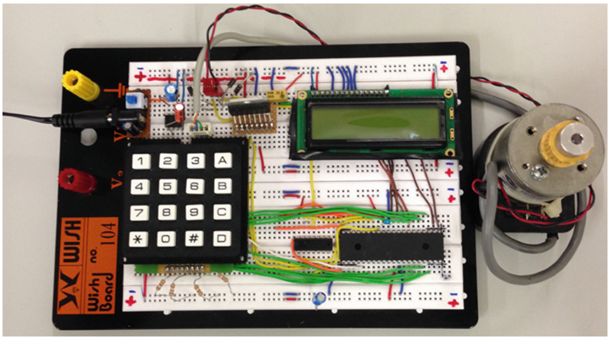


Fig. 2. DC motor control using microcontrollers

a reference of the angular velocity of the DC motor from the encoder. The angular velocity of the motor was controlled through a motor driver using the PWM signal from the PWM module within the microcontroller. Several variants of the PID controller where implemented. The angular velocity and the controller parameters could be input via a keyboard module and the results were displayed in the LCD module.

Since the microcontrollers theme was introduced that year and only 10 lecturing hours were reserved to this subject, the results shown by the final project that was submitted by the students show the high degree of autonomy demonstrated by the group, highlighting the strong incentive to research solutions to the problems that were being encountered during the project and the self-learning capability of the group. This high autonomy is also represented by the fact that the group had close to none contact with the C programming language and were able to timely learn it. Also, being able to implement discrete control algorithms on the firmware of the microcontroller highlights the interdisciplinary of these projects, allowing the students to apply knowledge from other course such as the Control Systems course. The diagrams of some of the implemented closed loop controllers are shown in Fig. 3.

This course allow the first contact with project of embedded solutions, as well as the first use of the closed loop control systems concepts into a real application which could have many potential applications at the industrial level, since the use of customized embedded circuits based solutions for more cost and power efficient industrial applications has been increasing when compared with the most classic implementations such as PLC based solutions.

3.2 Industrial Robotics

Under the Industrial Robotics course, an optional group project related to the study and offline programming of industrial robots was done in order to simulate a robot cell in virtual environment.

This project consisted in the design and programming of a robotic cell dedicated to handling operations. Thus, the work started with the implementation

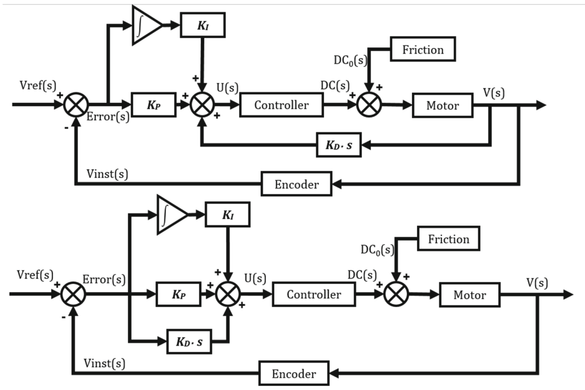


Fig. 3. Diagrams of some PID controller variations implemented

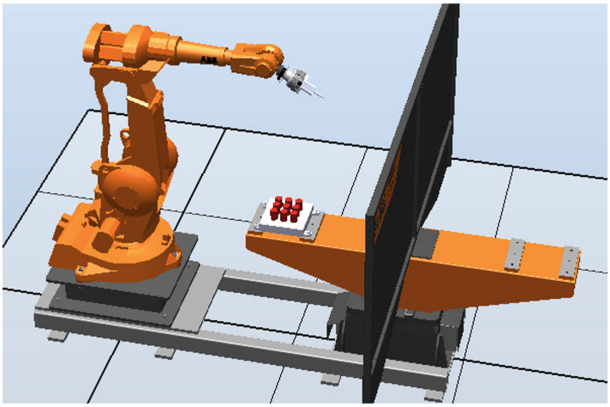


Fig. 4. Representation of the robotic cell for handling operations on a virtual environment

of a robotic cell in a virtual environment, able to demonstrate the robot's operating capabilities to describe complex trajectories at different speeds around a labyrinth consisting of a grid of cylindrical objects, as shown in Fig. 4 [8].

Furthermore, the group has developed an interface for allowing the console FlexPendant user to define the trajectory to be executed by the robot around the maze, among other drive parameters. This application for FlexPendant console is still capable of changing properties of the virtual station and even to read, edit, and automatically generate parts of RAPID code associated with the defined work path of the robot. This interface (shown in Fig. 4) was created using the Visual Basic programming language and potentialities .NET.

Due to a limitation of the robot's controller firmware version it wasn't possible to the group to test out the FlexPendant in the real robot, but it was fully working within the ABB software simulator.

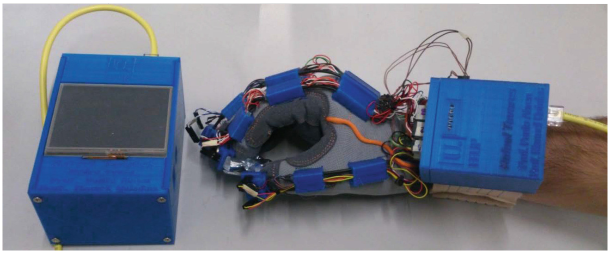


Fig. 5. Final prototype of developed device during the master thesis

With this project, we were able to learn to program robotic cells and managed to developed a powerful interface tool capable to generate RAPID code from the inputs of the user.

3.3 Master Thesis

On his last semester as a student, the author started his master thesis. He developed a project named "Passive device for hand rehabilitation" [9].

The project comprised mechanical design, instrumentation, electronic circuit design and programming which lead into a full implementation of the developed concept. The developed monitoring device represented in Fig. 5 used angular position sensors to measure the rotation of each joint of each finger, and pressure sensors to monitor the force applied on each fingertip. The system was controlled by an electronic circuit based on microcontrollers.

Furthermore, a modular architecture with two microcontrollers was used, one for controlling a touchscreen which acts as the user interface and another to process the analog signals from the sensors. Each finger of the glove had a vibration motor and a indicator light to provide a stimulus to be used in rehabilitation exercises. A graphical application was also developed in order to monitor each finger displacement and to implement rehabilitation exercises.

This project showcases the result of the acquired experience from past multidisciplinary courses which have all contributed for the success of this particular project. The development of the sensors and the signal conditioning was possible thanks to the Instrumentation for Measurement course and this has also been a great opportunity to integrate knowledge related to instrumentation. The knowledge and capabilities gained on embedded electronic circuits designing and microcontroller programming were also a very important contribute from Industrial Computing courses.

During the developing of his master thesis, the author was working at the Laboratory of Instrumentation for Measuring (LIM), which gave him the opportunity to contact with some senior engineers and with other students in a multidisciplinar environment of backgrounds and activities. These individual thesis projects all involve design, experimentation and construction of physical systems.

In the process of developing their prototypes, the students gain a deeper understanding of the mathematical and physical concepts, according to Kolb's theory of experimental learning, than in simulations and virtual concept works [10,11]. Also, the laboratory atmosphere enabled peer interaction between all the members, contributed to the exchange of ideas and critical thinking between senior engineers and other master thesis' students and enabled collaborative learning. With this approach, the group of students could conduct their researches and developments within the concepts found in problem or project based learning (PBL) with the benefit of cooperative learning and research practice which can be highly motivating, creative and stimulating for both students, teachers and senior engineers [12].

This master thesis also took advantage of a 3D printer. Being integrated with the senior engineering team allowed the author to learn about 3D printing techniques, which helped in getting fully functional prototypes [10]. The relevance of the use of 3D printers to support project based learning activities is also implied.

3.4 Tutor of Junior University (U. Jr)

While working in his master thesis, the author was one of the tutors responsible for one of the activities of the Junior University.

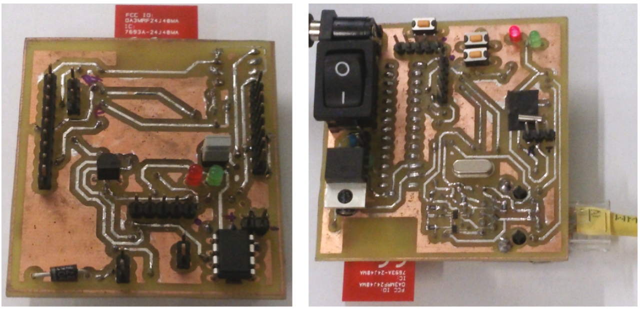
This initiative is promoted by the University of Porto and intends to engage students with ages between 11 and 17 years old to activities related with higher education. U. Jr is an example of a project-mentoring approach at two levels. The academic staff member responsible for each action acts as a mentor of the junior tutors, who are final year students, recent graduates or in some cases junior researchers. On the other hand, the tutors mentor the younger students who attend the various activities that integrate the U. Jr program [13].

Within the "Discovering Mechatronics" workshop, the author was a tutor in charge of a 14 pupil group during a full week of activities related to mechatronics, having the real challenge of interacting creatively with them, stimulating their curiosity and leading them into collaborative and active learning.

Since the author also had the opportunity to join these activities as a K-12 student, being part of the tutor team of this U. Jr activity shows that these initiatives are important in order to captivate new students into the Integrated Master's in Mechanical Engineer.

4 While Fellowship Researcher

The experience and contact with the research environment on the latest works led the author to be invited to integrate the System Integration and Process Automation Unit (UISPA), a research unit within LAETA-INEGI, in September 2014 for continuing developments mainly related to embedded systems. The critical thinking developed with the team and the healthy and proactive discussion of ideas along with the work developed during his master thesis lead to engaging new projects.



(a) Electronic Lock's PCB (b) Router

Fig. 6. Prototypes of the developed system

4.1 Network Management of Door Locks Project

The first project as a fellowship researcher was the development of a system for wireless control and network management of door locks, shown in Fig. 6, to respond to an Industrial requirement for an innovative system. Previous familiarity with multidisciplinary subjects, teams and environments were of great relevance for the success of the project, taking advantage of former knowledge on the embedded electronic circuit designs, firmware development and communication protocols. This project allowed further research and implementation of different wireless protocols, such as BLE and NFC to manage and control multiple door locks.

In this context, the embedded circuits of the electronic locks that control the physical lock, the custom routers that route information from the multiple locks to the main server and the applications for smartphones to work as the authentication devices were all developed by the research team. A demonstration of this wireless control system was presented at Exp.at'15 exhibition session [14].

4.2 Instrumented Glove Project

Recently, further developments have been made in the Instrumented Glove project within the UISPA research unit. The high motivation for the research and development field and the mindset of teamwork and support transmitted within the research group lead the author to carry on. Also, the development of health and rehabilitation devices as a commitment of providing solutions to help society has driven the author to continue improving this project that started as his master thesis.

Regarding the glove prototype, the graphical module was deprecated and the electronic circuit was restructured and the print circuit board (PCB) was rebuilt from scratch. With that restructuring, an IMU (inertial measuring unit) was introduced in order to track the hand position and orientation a new microcontroller was used for managing the USB connection with the computer and a

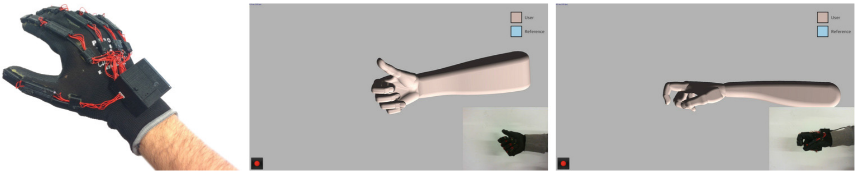


Fig. 7. Virtual environment with the second prototype of the instrumented glove

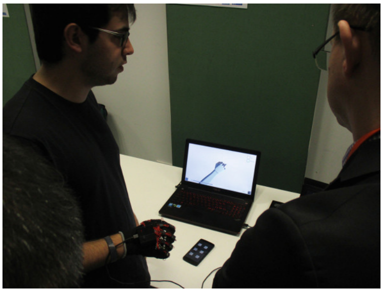


Fig. 8. Presentation of the Instrumented Glove project in the demo session of REV'16

Bluetooth Low Energy antenna was also added to the system for wireless communication with mobile devices. A rechargeable battery and the charging circuit were also added.

With these hardware improvements it was possible to create an online hand rehabilitation platform in order to promote rehabilitation exercises at home. This platform allows patients to use monitoring devices in order to carry out rehabilitation exercises represented on a virtual environment. The data collected throughout these exercises is stored either in a local or a remote database, whereas the latter enables further analysis and replay of the exercise by a therapist. The online platform also provides a multi-user online interaction in real-time, allowing a single therapist to connect with many users in a virtual lobby (Fig. 7).

The several improvements of the project were presented in demonstration sessions within several conferences regarding virtual instrumentation and experimentation [15–17] and got a successful engagement by the conference participants as shown in Fig. 8.

The representation of the collected data that is stored in the database was adapted to WebGL and can be accessed from the "Online Experimentation @ FEUP" website [18].

Nowadays, the author is still involved in this project working on an online platform to promote rehabilitation at home, studying improvements to the sensing solution of the instrumented glove and in the UISPA's objectives, as a social commitment, of developing online health devices and affordable solutions in order to help treating and preventing disabilities to better support the future increasing rate of population ageing.

5 Conclusion

The projects activities in which the author was involved definitely contributed to an improvement of his own, both as a professional and much more as a person. Although several studies and smaller project are usually given to the students as assessments of some course, they do not have the same motivation effect has the described projects.

After five years as a student, the author truly recognizes that the demand for voluntary extra work related to the topics covered in the different courses that came with his curiosity and ambition to improve his knowledge was totally worth. The ability to learn something in a real environment is much more rewarding, rather than be constrained by theoretical learning activities.

Furthermore, being involved with these projects promotes learning subjects into a deeper level of understanding, leading to stronger and better reasoned ideas. While in a group project helps us to improve our individual responsibility as a member of a team while being in charge of a specific task. These activities not only take advantage of the productivity of working as a team and also rely on critical thinking and the interaction involved in the discussion of ideas helps to clarify some of our own doubts and misconceptions.

After this self-reflection, the author recognizes that many of this experiences helped to improve his maturity, sense of responsibility and contributed to a widen knowledge and a greater capability of being a team worker. In conclusion, some of the technical skills acquired or strongly improved with the project activities were:

- Numeric simulation using Finite Elements Method;
- Electronic Circuit Design;
- PID Control Systems Design;
- Microcontroller Programming;
- Programming Languages: C, C++, C#, HTML, Java, MatLAB, PHP, RAPID, Visual Basic;
- Printed Circuit Board Design;
- Communication Protocols: NFC, BLE, MiWi;
- Mechanical Design and CAD/CAE;
- 3D Printing;
- Unity3D Developer;
- Implement Databases;

Some of the soft skills learnt or strongly improved with the project activities:

- Learn to work in group;
- Present and demonstrate work;
- Time management and meet deadlines;
- Critical thinking in decision-making processes;
- Leadership;
- Self responsibility;
- Persistence and perseverance;

– Resilience to face adverse problems;
– Technological and scientific writing of documents;
– Expose and demonstrate results;
– Ability to communicate well to other members of the team;

Acknowledgements. Acknowledgements to FEUP - Faculty of Engineering of the University of Porto, LAETA - Associated Laboratory of Energy, Transport and Aeronautics, INEGI - Institute of Science and Innovation in Mechanical and Industrial Engineering.

The author would like to especially thank all the UISPA research unit, especially the members of the research team in which he has been working lately.

Finally, special thanks are due to International Society for Engineering Education (IGIP) for supporting the "Young Scientist Award" and for providing the opportunity to self-reflect on all of those experiences and share them with the scientific community.

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K-12 and Pre-university Programs

Model for Improving the Quality of Graduates and Job Applicants in European Labour Market

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Abstract. Technical and vocational education and training (TVET) makes a significant contribution to economic competitiveness and welfare in a global knowledge-based economy. The main challenge for vocational education and training is to meet the changing skills needs of individuals and the world of work in accordance with the principle of lifelong learning. Authors introduces the project "Model for improving the quality of graduates and job applicants in the European labour market" elaborated and submitted by the two Slovak institutions of higher education - Dubnica Institute of Technology in Dubnica nad Váhom and the University of SS. Cyril and Methodius in Trnava, Slovakia. The paper presents research results of the Slovak National Project supported by the Slovak National Grant Agency KEGA. Below, we are focussing mainly on evaluation of methodology for improving professional language competences of students of secondary technical and vocational schools through the so called "Project Semester".

Keywords: Technical and vocational education · Training · Quality system · European labour market · Key competences · English for specific purposes

1 Introduction

Since the demand for new skilled workers is increasing, and the TVET customer base is constantly diversifying, it is necessary to increase awareness of the key role played by education and training in economic competitiveness and social inclusion. As in other EU countries, quality assurance in Slovakia plays a decisive role in modernising education and training systems and in improving their performance and attractiveness. These objectives are widely shared by the Ministry of Education of the Slovak Republic. Education and training systems are being modernised and transformed in terms of more effective management systems and quality assurance. The paper presents research results of the Slovak National Project "Model for improving the quality of graduates and job applicants in European labour market" supported by the Slovak

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National Grant Agency KEGA. Former results were presented at the IGIP conference in Florence, Italy and in Austria, and currently the Project is approaching its final stage. The results will be implemented into educational practice.

2 The Project Goals

The paper responds to current situation and deficiencies in the educational system of technical and vocational secondary schools in Slovakia in training of qualified workforce for the local and global labour markets. The main aim of the project is the development of a model for improving the quality of graduates and job applicants in European labour market. It focuses on graduates of secondary vocational schools in Slovakia and the acquisition and improvement of their key competences. The pilot stage of the Project dealt with theoretical background of quality assurance and specifics of its application in the area of technical and vocational education. In further stage, the project team developed a model for improving the quality of graduates and job applicants, based on the formerly applied model of quality at the Dubnica Institute of Technology, developed and tested in the last five years and thus sufficiently verified. Authors describe the development of quality management system. The research team clearly identified the documentation of educational process, quality of teaching, management of documentation and records, implementation of internal audits and other activities in this area. These processes constitute an integral part of building quality assurance at secondary technical and vocational schools in Slovakia. The project also solves the dissemination and feedback as a continuous process in close collaboration with the national Ministry of Education. The above mentioned procedures were described in details in Proceedings of 2015 International Conference on Interactive Collaborative Learning (ICL) in Florence, Italy [1]. The project has three main goals:

(1) Building up, implementing, testing and adjusting to the needs of secondary technical and vocational schools a fully functional system of quality management according to ISO 9001:2008, so that it would be compatible with European quality standards, meet the needs of school managements, students and labour market [2].
(2) Developing a curriculum of the English language course for specific purposes, including methodology and readymade didactic materials for teachers (including teachers' guide) to improve students' English skills and communication competences for global professional environment [1, 3, 4].
(3) Improving students' information literacy and information and communication skills towards general and specific needs for global labour market (the goal was limited by a wide range of professional fields, therefore the didactic and teaching materials were developed only for the selected professional areas) [5–7].

There has to be mentioned, that we have evolved efforts to overlap the goals to achieve greater effectiveness of the project results.

3 Methods and Material

The added value of the project is given by the development of qualitative elements aimed on the improvement of TVET students key competences, in particular by the application of the elements of the foreign language communication skills improvement, increasing the computer literacy and enhancing the quality of teaching technical and vocational subjects of the target group – graduates of secondary technical and vocational schools in Slovakia. In the development of the research methodology towards the quality management development and towards improving a quality of secondary technical and vocational school graduates, we compared quality and effectiveness of technical and educational systems (Fig. 1).

The first step was to put together sophisticated research and executive project team. Since we are in the second year of a two year project, we can say that this step was successful. The team is not large, but it is purposefully made up of experienced older members with extensive experience in educational research, and the young, dynamic teachers and researchers. An important factor in the project played the fact that the project had a pilot phase, and objectives have been clearly communicated from the outset. Depending on the defined goals, the forms and methodology of the research were selected. As a basic common method, the method of needs analysis of the target environment was carried out in various forms. Regional meetings with the management of secondary technical and vocational schools were organised and the problems of the quality management and assurance were discussed. The minutes from the panel

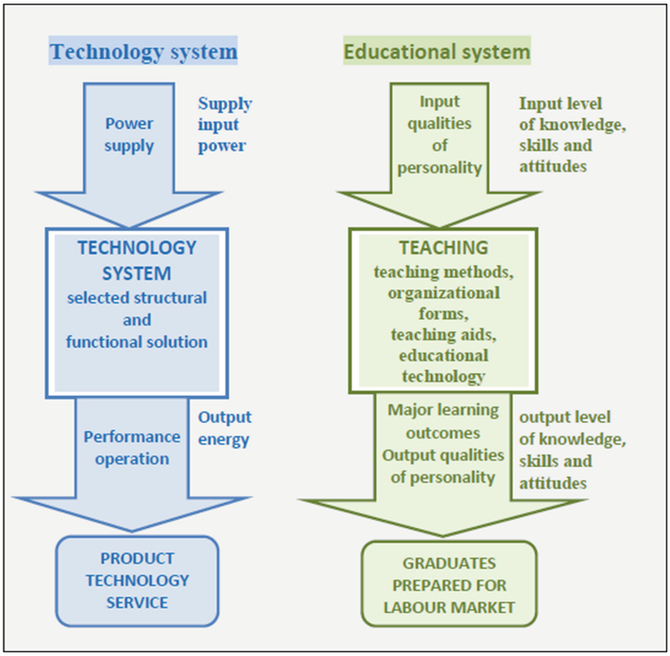

Fig. 1. Compared quality and effectiveness of technical and educational systems

discussions makes a part of the project documentation and serves as an important source for adjusting the Model of the quality for these schools. The Project team also visited selected schools in the region and all over Slovakia.

They discussed the needs and problems with teachers, school-management, but what is important, also with students themselves. Members of the research team through classroom visits become familiar with educational process. The field research played an important role in the development of the model of quality of education, but also in analyzing the needs of the target group of students, and the subsequent development of the learning and teaching methodical-didactic materials. During the project, several questionnaires were elaborated and distributed to the investigated target environment. In evaluating of the questionnaire survey, the possibility to compare results with the outputs of the pilot phase of the project, enabled to measure and verify the correctness of the output data. Moreover, we distributed questionnaires to more than 20 multinational and foreign companies operating in Slovakia, as well as visited the five of them, an discussed and tried to identified their needs towards the recruited graduates of secondary technical and vocational schools in Slovakia. In three cases (ZF SACHS Slovakia, a.s., Volkswagen Slovakia, a.s., and Matador Holding) we were able to contact young freshly recruited workers, graduates of secondary technical and vocational schools, to discuss their experience, needs and expectations.

4 Current Status Report

Secondary technical and vocational school graduates achieve the knowledge base in technical subjects and natural sciences: informatics, technology, mathematics, physics, chemistry, and in professionally oriented subjects. Courses in humanities and social sciences, including foreign languages, contribute to the general basis for their intellectual momentum and professional development. To increase the chances of in professional practice, it is necessary to acquire not only language but also professional communication competence. Professional communication language skills along with other key competences play an important role in professional career.

English as the international language of professional communication has been so thoroughly acknowledged [8] and its dominance is barely doubtful. Teaching English in the environment of secondary technical and vocational schools should not be limited to only textbook and classroom activities, and certainly not to teaching General English. With the development of teaching English, it has become necessary to define and distinguish the types of courses in order to elaborate the methodology and specify the content. Besides general English, the term English for Specific Purposes (ESP) has been used in a broad sense to refer to a wide range of very different “occupationally-oriented” courses.

5 Research Results

Research has shown the necessity of introducing the quality system in order to increase the level of graduates by improving their studies and training for the specific requirements of the European labour market, which may vary depending on specifics of the industry, but it also showed common needs. The outcome that is expected at the final phase of the project, but is fully prepared now, is the “Model for improving the quality of graduates and job applicants in European labour market”.

The further project outputs are aimed to improve the quality of teaching of English through professionally oriented language portfolio based on the needs analysis of target groups and the creation of modern, content-compatible and effective set of teaching materials (textbook, workbook, dictionary, multimedia device, teacher book) for selected types of secondary technical and vocational schools. They are closely connected with a specific methodology that is going to be presented through a series of methodology meetings and workshops for teachers of languages at the target schools. We implemented the computer literacy and ICT skills and competences in the Project in a multidisciplinary way. Firstly, we developed multimedia teaching tools on the e-learning basis. We created a multimedia tool as part of the teaching materials of selected course (Electrical Engineering). We measured the impact of the use of multimedia tool for teaching quality and the performance and satisfaction of students with a focus on psychomotor skills. Secondly, we are going to apply the project-based teaching to improve both computer literacy and ICT skills and competences implementing foreign language communicative approach within content and language integrated learning.

Based on the knowledge that secondary technical and vocational schools prepare students in the field of language training just in general English as a preparation for final exams, there is a lack of specific targeted language training for professional environment. According to the feedback from recruiters and potential employers, they would prefer a graduate with flexible and complex language competences. It means, graduates, who are able to communicate and understand a standard general instructions, but who master specific technical vocabulary and are able to actively (and linguistically correct) use specific professional genres (report writing, memo writing, e-mail writing, oral presentation, effective PowerPoint slides, instruction reading, safety rules, etc.).

For this purpose, we have developed a specific course of English for Specific Purposes, that can be adjusted to any professionally oriented field at secondary technical and vocational schools. We divided the courses two parts and so far we tested the first part called the Project Semester. It consist of the two lessons per week and is build-up upon project-based teaching. There is the need to mention, that all the methodology as well as the curriculum of the course was developed strictly upon the needs analysis of the students’, teachers’, and the target environment of labour market needs.

We addressed management of two schools in the regions: Secondary Technical School of Electrical Engineering in Trnava, and Secondary Technical School of Electrical Engineering in Piešťany, Slovakia to make an experiment in classes of 3rd and 4th grades with a sample of 17–18 years old students in experimental and control groups. According to the state curriculum, students at both schools have three compulsory lessons and one optional (conversation) of English per week, and at the end of the fourth grade they pass school leaving exam in English having a possibility to select the level according to the Common European Framework. It was due to the small number of contact hours (lessons), that the experiment expected increasing English language lessons and, according to the specific course methodology of project-based learning, activities beyond classroom with an aim to raise language skills and professional communication competences, motivation of students to learn English and their awareness of its usefulness towards their future professional life. The experiment expected the development of teaching materials, methodology and preparatory training process with teachers of English. According to the state plan of curricula, the managements of schools were able to include two additional lessons of the course of specific English for professional purpose into the teaching plan of schools. As an outcome of the former pilot research, we implemented project work into the teaching process and tested its efficiency in two school semesters in 2015–2017. Since the last semester was in a progress at the time of writing the paper, we were able to evaluate only results of the first (autumn) semester. The whole process was facilitated within the purposefully planed time schedule. In autumn 2015, we tested viability of the project work and range of its application to verify and precise the process of planning, elaborating and presenting the outputs of the project work, as well as to measure its efficiency in various areas.

So that to fulfil one of the goals of the Project, to investigate correlation of the use of information and communication technologies and teaching professionally oriented foreign language, we have prepared for students the project semester. The feasibility study of the project semester has been verified within the natural pedagogical experiment on the sample of 36 third grade students. Their knowledge of English was at Intermediate level after studying two years of the general English (and former learning of English at basic school) from "New Opportunities" textbooks (Pre-Intermediate/ Intermediate). We tested the functionality of the model, methodology and acceptability of selected outputs. We used observation as a method to verify the feasibility of pedagogical experiment in practice. The project focused on three objectives:

(1) Training and improvement in the technical vocabulary and practice of professional communication in using oral and written professional genres.
(2) Improving information and computer literacy of students.
(3) Increasing the share of time working with foreign language beyond the normal teaching.

At this stage, we have used direct action research aimed to enhance, improve and positively influence the educational process. The established practice of traditional methods of working with text was replaced by project teaching, i.e. teaching in which the project teaching is the dominant methodology. Students are facilitated to solve complex problems and gain experience through practice and experimentation. We were thus enhancing the flexibility of the students, their creative thinking, strengthening their communication skills and developing a positive creative atmosphere. Involvement and use of ICT purposefully lead to increase student competence in this field and thus streamlined their education. For the background and skills that are necessary to practice, acquire or improve, we chose a set of selected knowledge and skills from ECDL syllabus. Choice we have implemented based on empirical analysis of frequent errors and deficiencies that students make in their involvement in solving problems of ICT in the learning process. Measurements were compared with measurements of the pilot phase of the project (2013, 2014) for two independent, structurally and size-compatible sample. We selected a set of knowledge and skills from ECDL syllabus as the background and skills that are necessary to practice, acquire or improve. The selection was implemented on the basis of empirical analysis of frequent errors and deficiencies that students make in their use of ICT in solving problems in the learning process. Measurements were compared with measurements of the pilot phase of the project (2013, 2014) on two independent, structurally and size-compatible samples.

For the project, we have chosen the issue of "the History of Inventions". At the beginning of the semester, students become familiar with the project itself, its rules, timing and desired output. The project was spread over ten weeks of the 14-week semester so as to have a time reserve and time for evaluation. After the end of the experiment, based on the experience gained by observation, feedback, comments and observations of students, we analyzed the methodology of the project, its content and formal aspects. The project was carried out within the following syllabus and time schedule:

1st week

Selecting a topic: technical invention, discovery, development (it is good to discuss the possibilities in order to prevent possible misinterpretation, duplication, etc.).

2nd–3rd week

After topics approval, e.g. "History of metals discovery and processing", students search for, select and backup websites. They collect and process the initial text in MS Word on one side of A4, font Times New Roman pt. 12, 2.5 cm margins, single spacing, justified, with referred resources and the name of the student (!). Word processed text students send as e-mail attachments to the teacher.

4th week

Analysis of the correctness and etiquette of electronic mail and the sent texts, common mistakes, discussion on the used computer skills (copy, paste, format, language settings, spell checking, removing hyperlinks, using the tab key, …), netiquette (e-mail etiquette), proper sending of formal electronic news.

5th–6th week

Poster processing - sample (Fig. 2), send by e-mail:

- In MS Word format, A4;
- Upper area: one quarter, column heading included personal and professional data (name of school in English, word wrap;
- Lower area: three-quarters, two columns (different style has to be discussed);
- The main text of approx. 2000 characters single space, any kind of technical font;
- Pictures, photographs, illustrations.

7th–8th week

Analysis of posters, discussion;

Task: Preparation of oral 5-min presentation with PowerPoint support;

- Seminar on "How to efficiently design presentation PowerPoint slides";
- Seminar on "How to successfully present the oral presentation";
- Poster - Transformation MS Word file into a PDF file;
- Submission of a poster (PDF) and PPT presentations in compressed files;
- Printing a poster (regardless of submitted files).

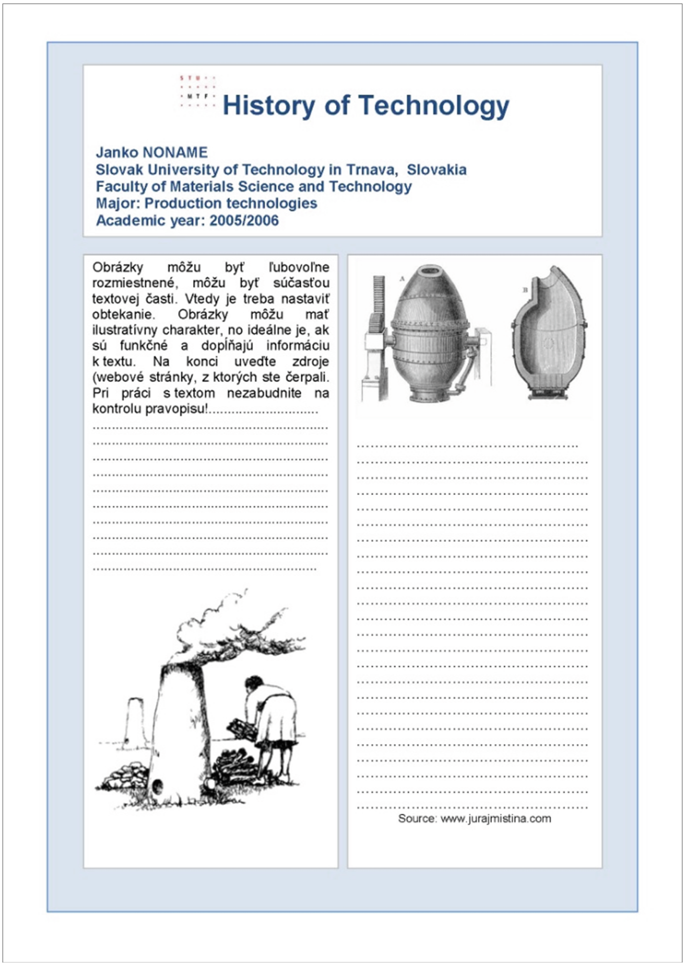

Fig. 2. Sample of the poster graphic design (not template)

9th week

Presentations of selected topics; evaluation of presentations, exhibition of posters, the best poster competition.

10th week

Evaluation of project activities, discussion.

After the semester course, we analyzed the experience gained by observation and informal conversations with students. The analysis led us to the fact that this project after minor adjustments is suitable for the intended project semester and is effective in the development of language skills and improving communication and information competences.

Results of the analysis and proposed solutions:

- Of the planned 10-weeks, the experiment stretched up to 12 weeks. It will be necessary to improve the course time management by increasing the share of electronic communication with individual students and with the whole group. Theoretical and practical lesson aimed at preparing for an oral presentation move into the third or fourth week. Reduce some selected tasks.
- Some students had a problem with printing the poster. Consider a poster only in electronic form. Provide centralized printing. As one of the top rated activities by student was the competition for the best poster.
- Part of the students was charged with the task of compressing files. Keep this task merely as voluntary.
- Many students have chosen Wikipedia as a source. Establish criteria that Wikipedia cannot be used as the main source for project solution.
- For the oral presentation of the project, two weeks should be allocated.

We were interested in qualitative assessment. At usefulness, students in both experimental groups oscillated between presentations and electronic netiquette. Finally, the majority of both groups agreed that the presentation, including the preparation of the creation of PowerPoint slides was the most useful activity for them. They appreciated that the information was new to them, and that they were given it in the context explained. They expressed the assumption that they will use this experience in professional practice. On the direct question how many of them knew principles of e-mail etiquette prior to this project, only 4 of 36 declared the knowledge. 7 of 36 students considered work on the poster as too difficult. Two students identified it as unnecessary. To the question "why?", they answered superficially: "What good will in life the "poster" be for?" After discussion, and explaining that it was not a poster itself, but work with technical foreign language text, while poster was just a form that defined limits, and that while working on the poster they had to train more computer and language skills, they eased their arguments, but insisting that this activity was difficult. While so far both groups agreed in all tested parameters, in assessing demandingness, any of the students in second group did not indicated poster as difficult. This interesting phenomenon can be explained that in verification of the activity in the pre-research and then in the experimental group, we precised methodology so that the task was clearly articulated and clearly indicated. The difficult one was designated the task in identifying sources, materials selection and processing of primarily reduced text. Activity was marked as time-consuming, some students said that the most difficult was the choice of subject itself. The second group did not think that any activity was unnecessary. On the contrary, they appreciated their applicability.

6 Conclusion

The main benefit of the project is the development of the model for improving the quality of graduates (secondary technical and vocational schools) and job seekers in the field of the European labour market (mainly focusing on improving language communication competences and computer literacy of the target group). We expect the impact of activities implemented in the project on specific target groups: citizens, employers, public administration, etc., but especially on educational institutions and the learners. We prepared and designed universal modern tools to implement to improve teaching and learning towards the quality improvement, particularly the quality of the school graduates at the European labour market.

We are aware of the fact that project work is not a cure for everything. It requires a highly professional preparation, field analysis, it is more demanding but also more satisfying activity them traditional methodologies, and that for teachers and students as well. It expects a teacher with advanced methodological competencies. As we mentioned in the introduction, project work is not a method. It is up to the teacher what methodological approach s/he will decide for within this demanding educational process, so that to achieve the efficient and effective results that would satisfy both students and the teacher. The benefit is that many other key competences required by labour market are developed, particularly creativity. Ultimately, they are the prospective future employers of graduates, demanding for workers with high language competence, who should be satisfied. Project work is one of the means to attract, challenge and involve students in their professional development.

We described a dominant part of our project. Currently a demanding task of wide national verification of the so far achieved results is in the state of launching the activities. We addressed 40 secondary technical and vocational schools all over Slovakia, and got positive responses to enter the process. We prepare and design universal modern tools to implement them to improve teaching and learning towards the quality improvement, particularly the quality of the school graduates at the European labour market.

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Ciberlandia: An Educational Robotics Program to Promote STEM Careers in Primary and Secondary Schools

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Abstract. Robotics in education is considered as a powerful tool for motivating and training students. Thanks to its multidisciplinary character, it allows for the development of the contents of a multitude of materials, mainly those related to Science, Technology, Engineering and Mathematics (STEM). This has been demonstrated in many studies and experiences that have been developed around the world over recent years. However, despite the undoubted benefits and the various initiatives, many educational communities have serious difficulties implementing this tool in the development of their curriculums. The purpose of this article is to present Ciberlandia, a real learning experience that responds to these difficulties and helps to extensively promote careers in scientific and technological disciplines for youngsters. This initiative has celebrated 4 editions and has involved 2,480 participants from 53 primary and secondary schools in The Canary Islands.

Keywords: STEM education · Educational robotics · Robotics competitions

1 Introduction

In recent years, the demand for qualified professionals in Science, Technology, Engineering and Mathematics (STEM) has grown substantially. So much so that the human resources departments of companies seeking to recruit new staff often face certain difficulties in finding qualified personnel. Despite this circumstance, degrees related to these areas continue to be less in demand than others. Another disturbing fact concerns the gender imbalance this is reflected by the low representation of women within these disciplines across the board, especially those related to engineering and computer science [1]. This fact suggests that certain stereotypes between men and women still remain in society which are proving difficult to break. To try to solve this problem, many institutions have decided to launch initiatives in order to promote the STEM careers in different areas of society. In this context, educational robotics and the creation of project-based learning environments have become very powerful tools both

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for designing promotional activities and training activities. Some of the best known initiatives around the world are the competitions FIRST [2] BEST [3], VEX [4], WRO [5] and Botball [6].

In the year 2012, the University Institute of Sciences and Cybernetic Technologies (IUCTC) linked to the University of Las Palmas de Gran Canaria (ULPGC), in collaboration with other organizations from both the public and private sectors [7], carried out a study of the state the arts in The Canary Islands. Based on this report, they decided to set up the educational initiative known as Ciberlandia: Education, Robotics and ICT. Ciberlandia seeks to promote scientific and technological vocations to school children, aged between 11 and 18 years, with a particular focus on girls and women. This is done through providing experiences and training activities related to science, technology, engineering, mathematics and computing, framed in a multidisciplinary environment and through robotics. The activities are designed to allow participants to come into direct contact with the university and research being carried out by engineers and professors linked to IUCTC (Fig. 1).

Fig. 1. Different workshops in Ciberlandia

Since its inception in 2012, this project has arisen through collaboration and joint work between agents and organizations of various kinds in order to create synergies, mobilize more resources, multiply the capacity to make an impact, and build learning spaces involving different areas such as the social, educational and business spheres. The result of this collaboration are the four editions that have been held, coinciding with the academic years between 2012 and 2016. The initiative takes place in competition format so that participants present the best of themselves in order to reach the most advanced stages of the initiative. The theme of the activities of each edition is different and acts as a motivator for students. In the development of each edition, teacher-led classroom training is combined with autonomous elements through the development of workshops in schools and the distribution of a series of contents using telematic services via an online educational platform. In this way, the presentation of a series of activities is also proposed. Thus, the teacher-led classroom sessions become extremely effective practical workshops for experimentation thanks to the students arriving already prepared from the autonomous training.

The promotion of scientific vocations within this initiative is implicit and takes place through quality, cutting-edge training, facing the actual needs that our society demands. Ciberlandia has been developed in the territory of the Canary Islands, Spain, specifically on the islands of Gran Canaria and Fuerteventura [8]. Neither the remoteness of the locations, nor the rugged terrain of the geographic area have impeded the success of the initiative.

2 Discussion of Related Work

Educational robotics tournaments worldwide such as WRO, FIRST Lego League or Botball have achieved in many of their participants a great impact in terms of the development of skills related to communication and teamwork, also helping them to increase their interest in STEM careers. In addition, in order to face these competitions, they must prepare themselves academically in various areas such as science, technology, mechanics, electronics and computer science. All of this is achieved in a way which is extremely enjoyable and motivating for them. A great deal of literature is available regarding the benefits of the use of robotics in education [9–11].

Despite the benefits that these competitions bring for participants and the increasing number of adherents around the world, many educational communities remain marginalized from such initiatives, even having some difficulties developing activities at the local level. The main obstacles they face are the lack of financial resources for the acquisition of the necessary equipment, such as robots or computer equipment, and a shortage of qualified personnel to carry out these initiatives [9, 10]. In addition to these circumstances, some experts point out some weaknesses of these competitions:

- The challenges and work materials used are perhaps focused more on the participation of boys, being less attractive to girls [11].
- Some of these competitions require a financial outlay in respect of work material, as well as transport to the venue of the competition. It seems clear that some economically disadvantaged students may find it difficult to participate.
- In these competitions in which a team of between 3 and 8 schoolchildren - accompanied by a monitor - must be presented, those chosen will probably be the ones who were initially already the most motivated by the subject matter, thereby reducing the chances of awakening curiosity in other students about the tool, hindering the promotion of STEM to students with different profiles.
- In the opinion of the authors of this work, these initiatives are specific events and not educational training programs. The training of members of these teams depends on them being responsible for themselves.
- Between different teams, which perform tasks in isolation, there is a lack of communication in solving challenges. This is probably the result of the competitive nature of the event. In fact, in the final assessment, work is exhibited before a panel of judges and scored behind closed doors, so that the projects developed by each team are not seen by one another.
- Time and quantity are rewarded more highly than quality. The judges of these competitions do not come to value the quality of the solutions proposed - for example the level of programming - but rather they focus merely on the execution in terms of time taken to complete the task, which governs the rankings. In fact it could even be the case that the program was not developed by the participants

themselves or that the judge was unaware of the tool with which they programmed the robots.

- The materials allowed for completing the challenges are limited to the use of a particular commercial brand, limiting the diversity and creativity of the solutions.

After a study of art in the Canary Islands in 2011, the IUCTC was able to verify some of the obstacles discussed above so that they did not carry out initiatives based on robotics in education at that time in this geographic area. This tool was reserved at that time for exclusive use at the university level in the development of a few subjects. It was at that moment that Ciberlandia was born, a program to extensively promote STEM.

3 Objectives

Ciberlandia's fundamental objectives are:

- To bring into focus and make accessible educational resources of a technological nature in order to encourage experimentation in non-university students aged between 11 and 18 years, promoting to them vocations of a scientific and technological nature through the use of tools that enable direct contact and experimentation with research methods and practice.
- To bring science closer by conducting creative activities in which students plan, implement and evaluate projects that have application in the real world beyond the classroom. These projects:
  – Focus on active student participation.
  – Have a defined start, middle and end.
  – Provide significant content which is directly observable in the environment.
  – Solve real-world problems.
  – Combine academic knowledge with vocational skills.
- To allow feedback and self-assessment by participants, promoting understanding of concepts related to innovation, curiosity and scientific interest on a personal level, as well as creativity and innovation at the professional level.
- To encourage the participation of the general public, researchers and research centers in the dissemination of scientific work and results among the younger generation in an environment of ideas and development of entrepreneurial projects.
- To arouse the interest of school teachers to work on participatory and innovative methodologies such as those presented in this project.
- To foster closer ties between business, entrepreneurs, researchers, educators and the family. Thanks to the collaborative commitment to this project of entities from those diverse fields, entrepreneurial spirit at an early age would also be encouraged.

4 Methodology

The methodology used in Ciberlandia is based on constructivism of Piaget, Papert and Resnick [12–14]. It is also based on project-based learning and has created the basis to respond to a number of existing needs [15]. Trial and error form part of the active and meaningful learning experience of the participants. This approach helps to understand how ideas are understood and transformed when expressed through different means. This theory is based on the art of learning to use technology. Constructionist theory believes that meaningful learning is reached when young people are involved in their own learning experience, such as in the construction and programming of a robot. Construction of and interaction with these devices ensure that raw materials in cognitive processes lead to a more robust and durable form of learning, since, as Piaget and Papert assert, young people are the builders of their own cognitive tools and external realities.

In general, environments of transdisciplinary learning are provided where students acquire skills to construct research projects and solve specific problems, training people with the ability to develop new skills, new concepts and give efficient responses to changing environments in the world today. It is an experience that contributes to the development of the creativity and critical thinking of students.

5 Academic Program Design

Ciberlandia is a lively and accessible project that has evolved based on feedback received from the participants. The format of each new edition is enhanced by the experiences of the previous one and further enriched by the opinions and suggestions of the participants. The following considerations have been collated from the previous edition:

- Over the course of the program, everything necessary for the development of activities is made available to schools, both in terms of human and material resources.
- All activities carried out are formative in nature.
- The initiative is held in a "semi-presential" or blended format.
- The teachers of the students at participating schools form an active part of the experience.
- The aim is to reach students who have an existing interest in the subject, as well as those who don't. All students involved should be part of the learning process and the development of activities. In this way, the end results represent the combined contributions of each participant.
- The material and personnel resources are distributed so that the maximum of students can be reached. Each school participates with a group of between 21 and 30 students. Up to 10 robotics kits are provided per group and workshops are developed by 2 monitors.
- The initiative is carried out in competition format in order to promote values related to effort, dedication and excellence. The challenges proposed must be complex yet

fun. The tools should be treated with affection and respect. Participants should learn about issues with which they are not familiar and have no existing expertise [16].
- The challenges and activities planned have a focus which lies beyond a mere playful game between opponents. Collaborative challenges do not seek confrontation. They arise so that different groups are coordinated to fulfill a mission together. The themes of the challenges are inspired by real-world problems.
- The groups are created with an eye on diversity, taking measures to prevent students from forming groups according to their own personal preferences and trying, where possible, to ensure that each group is led by a female student.
- Some of the phases of the initiative are carried out in strategic promotion and dissemination centers: the university, acceleration centers for startups, technology parks, museums, and halls of congress.

In continuation, we will detail different stages that have already been present in previous editions:

5.1 Themes

The first step is to choose the theme on which to base the new edition Ciberlandia. The theme allows us to pose challenges based on any abstract concept. Students have a particular context that provides a reason and justifies the need for training to overcome the challenges proposed. Therefore, demand necessitates and demands immediate implementation of the contents to be worked. The themes of Ciberlandia so far have been: robotic support in emergency situations, smart gardens, the game of basketball, robotic ants with virtual robotic chemical pheromones, and robotic heliostats. The latter theme was inspired by a project in the Norwegian town of Rjukan, in which a number of heliostats were installed to try and provide a solution to the shortage of sunshine in this place. Through these devices, they were able to illuminate the main square of the town, making it a special point of meeting and reference for the neighbors (Fig. 2).

Fig. 2. Theme of Ciberlandia 2016 - Heliostats bring winter sun to Rjukan in Norway

5.2 Educational Content - Adaptation to School Curriculum

Once the theme has been established, the process of adapting the contents of Ciberlandia to the requirements of the proposed theme is initiated by trying to answer questions like: what can technology do in this context? Certainly, during the process of choosing the theme, the issue was taken into account but it is at this moment that the detail needed for realization is considered more deeply. It is necessary to design and build robotic units related to the topic, as well as design appropriate experiments, develop a line of discourse, and consider scenery and specific materials. Of course, the generation of educational content in accordance with all of this must also be carried out. These contents are prepared and adapted to the skills and the curriculum of the school year in which the participants are currently studying. It should be kept in mind that the workshops are held within school hours, so all material - including, for example, construction manuals for the robotic units or the different activities to be carried out by students - must be generated.

5.3 Telematics Training

The next step is the autonomous stage. For this, the centers receive access to an online course from which a series of educational contents developed during the previous phase can be accessed. In the workshops to be held subsequently, the degree of preparation necessary to make the most of these contents is evident since it directly affects the most efficient use of them. For example, if students have worked on the theoretical contents collaboratively with teachers, experience with the Ciberlandia monitors will be eminently more practical. It will not be necessary, for example, to spend time explaining what a sensor or an actuator is. At this stage, various communication channels are enabled so that teachers can direct any questions to us.

5.4 Workshops

After the telematics stage, workshops are held. In these, students come into contact with the world of robots generally through the development of various creative activities that exploit the concurrence of different disciplines. For example, building activities that allow students to feel with their own hands their constructions and programming activities that introduce students to an intangible reality such as logic.

Activities should be resolved in groups of two to three learners, each of whom receives a robotics kit with the parts needed. In order to evaluate the development of the program and the results obtained, a challenge is set for the class to solve during the final stage of the workshop. This allows students to apply learning in order to try and solve a problem. The students are motivated to face the challenge ahead, before their peers and themselves, applying what they have learned and assimilating that knowledge in order to solve the relevant problems. It is at this time that what is learned is understood and begins to make sense - doing is knowing. Of course, Ciberlandia is about ensuring that the process up to this point is entertaining.

In Ciberlandia 2016, of which this phase refers to, 42 5-hour workshops were held at the School of Engineering and the Technology Park in Fuerteventura. At other times, these workshops were held in the student's own schools. Each workshop is prepared to be given to an average of 30 students.

5.5 Preparation of Activities

Now that many centers have had the opportunity to sample the benefits of Ciberlandia for themselves, it is necessary to make an effort to try and secure their involvement. To this end, centers reach out and provide through the online distance-learning platform some activities to be solved in class. Advised by their teachers and at their own pace, through self-organization they apply themselves in anticipation of the next stage.

5.6 Meeting Event Between Schools

The activities of the previous stage are presented at an event attended by each of the institutions involved in the initiative with a group representative of students. In this event, they have the opportunity to learn how colleagues from other centers have worked together and also to publicize their own efforts. It is a moment to appreciate for several reasons, one of which is the global aspect that is acquired when students witness how the initiative transcends the limits of their class and school. The fact that it is representative of the students is itself a prize, as well as a reward for the individual efforts developed within the group.

At this point, it should be noted that those centers which have a representative team that meets gender parity, receive an additional score to reach the final phase of the initiative. At this time in many centers, an interesting controversy among parents, teachers, students and the Ciberlandia team is created. We encounter those who think they are more qualified than their peers because they are better prepared to face the coming challenges of the initiative. However, these challenges are not known beforehand since they are not published until the next phase of the advanced workshops. Centers whose initial group of 30 students is made up of students who have chosen as elective studies technology or computer-based subjects often find that there are too few girls in their groups to meet gender parity. In one form or another, a period of reflection is then generated that delves into the stereotypes perpetuated by society that, from an early age, have led to the current underrepresentation of women in science and technology-related fields. The initiative always seeks to highlight the importance of creating groups with diverse student profiles. At the end of the day, robotics is multidisciplinary and the activities proposed consist of problems that are solved through the combining of different skillsets, such as, for example, research, programming, construction, marketing and public presentation, preparation of multimedia material, and drafting of literature.

The next stage evaluates results and leads to the selection of centers for the advanced stage, following the assessment of a number of criteria for public selection. This, again, is a reward and an additional motivator for participants.

5.7 Workshops Prior to the Final

In following up on the previous stages, a series of advanced workshops that explore the content already dealt with are held and new content is presented. These should be applied in the resolution of a final challenge entitled “The Grand Final”. In this workshop, the complexity of the challenges increases. The purpose is to ensure that the skills and ideas acquired by students are strengthened and that, above all, they discover that there is much more they can learn. It is founded on a much stronger base of experience than previous meetings and encourages them to aspire to gain mastery of more advanced concepts such as the use of memory, logic gates, parallelism, or Bluetooth/WiFi communication. All of this exists in the context of resolving the final challenge, which is to be made public.

5.8 Ciberlandia Grand Final

As a climax to the project, The Grand Final is proposed to take place at an emblematic location. The Grand Final, as we have conceived of it, is a celebratory event attended by students from the selected centers who have participated in the advanced workshops and to whom the resolution of a technological challenge has been proposed, related to the contents previously taught and based on the theme of the edition. Meanwhile, their colleagues who have already participated in the initial workshop phase attend a series of conferences of a technological nature, for example, game design or construction of intelligent drones. Therefore, during the course of these talks, participants of the final must complete the work in the advanced workshops, this time with the final scenography and measured against teams from other centers. At the end of the talks, in front of their peers and teachers, and invited representatives of organizations that support Ciberlandia, as well as other collaborators and the media, the students exhibit the results of their work. Finally, a small ceremony is held which honors the effort and achievements of the participants and some final words are given in closing, offering encouragement to young people regarding the challenges they will encounter throughout their lives (Fig. 3).

Fig. 3. Some photos about grand final 2013, 2014 and 2015

5.9 Administrative Management, Planning and Dissemination

Parallel to the previously mentioned phases, the work of planning and management is carried out: opening phase of registration, selection of centers, calendar scheduling, establishing the timetables of participating centers, logistic decisions, procurement of materials, distribution and justification of the project to associates.

During the execution, regular coordination meetings and monitoring of each of the actions are carried out. Notwithstanding the provisions above, the management and technical units will be responsible for running as many special meetings as necessary for achieving the objectives.

In addition, the last phase of Ciberlandia involves producing the final documents, reports, explanatory/informational videos and the proposal for the overall budget of the project - material that will be used for project accounts.

6 Results

6.1 Impact

In celebration of the first 4 editions of Ciberlandia, a total of 2,480 students of primary and secondary school age, as well as 168 teachers from 53 different schools were involved, located in both urban and rural environments and from various urban and suburban schools located in The Canary Islands [8], specifically the islands of Gran Canaria and Fuerteventura. Some details of the different editions held are shown in the Table 1.

Table 1. Participation statistics

2012/2013	2013/2014	2014/2015	2015/2016
Schools involved			
6	14	22	42
Number of different students and teachers involved in workshops			
192	378	594	1,316
Number of basic, advanced, Preliminary and Grand Final workshops			
13	21	31	58

The growth of Ciberlandia over the years should be noted. Moreover, the success and impact of the initiative has led to various organizations inviting Ciberlandia to participate in different events and activities related to the dissemination of scientific and technological culture in The Canary Islands. These activities have been conducted in parallel with the celebration of each of the invitations. Some of the most important are: (Fig. 4)

- Researchers' Night 2014 and 2015.
- Science and Innovation Week in the Canaries 2014 and 2015.
- Encounters with Science 2014.
- Council of Santa Lucia de Tirajana 'Awaken Vocations'.

Fig. 4. Some activities related to the dissemination of scientific and technological culture

- Classroom Teacher Training, CEP Fuerteventura.
- Open Day 2016 at the School of Engineering at the University of Las Palmas.
- Gran Canaria Gamer 2014/2015.

Participation in each of these events is documented on the website of the Ciberlandia initiative [17]. From the work developed over the years, there are some results that we consider appropriate to share with the community. These are:

- The achievement of the objective to foster vocations of a scientific and technological nature through a quality and eminently practical training program, the result of collaboration between diverse organizations of various kinds, led and carried out by the university.
- The transformation of participants from the usual role of consumer, to which they have been accustomed, to the role of designers and builders of their own products and services.
- The provision to the community of a model for the implementation of educational programs that encourage the use of educational robotics in geographic areas in which well-known initiatives could not reach extensively due to lack of resources or qualified teachers.
- Distribution of a series of educational contents generated in the development of the initiative that can be useful or at least inspirational. These contents have been previously shared in the section entitled 'generated material' and include videos, designs of robots, instruction manuals and programming resources.
- Evident stimulation within the teaching faculties of participating schools to learn about and undertake future educational projects.
- The search for and dissemination of mediums of communication for quality, educational-related initiatives emanating from the public domain.
- Development of the tools that permit research using the materials obtained in the Ciberlandia initiative and that contribute towards extending its possibilities. This is the case with the development of new libraries and APIs (Application Programming Interface). The achievement of this outcome is evident with very concrete results such as the WiFi/Bluetooth communication used in different proposed challenges.
- While it is a fact that it cannot be attributed solely to the existence of Ciberlandia, we wish to emphasize the impact that has been experienced in education in The Canary Islands in terms of the DIY (Do It Yourself) philosophy and the use of robotics as a tool for experimentation and learning different disciplines and fields of

knowledge, not only with formally connected centers. In fact, since the beginning of Ciberlandia in the geographic area in which the initiative developed, different companies have been created that provide training courses for school-based robotics and/or technology in general: Bizkidzlab, The Robot Factory Gran Canaria, LPA Fabrika, AOSS.IO Education, Robotix Canarias and Aula 3i. In fact, some of the promoters of these ideas are teachers who have previously participated in Ciberlandia. Other indicators following this type of outcome are:

- Several schools in the same geographic area have begun offering educational robotics as an extracurricular activity. One school has even implemented it as part of their curriculum.
- Some schools at this time have been encouraged to participate in European projects related to educational robotics such as the IES Vega de San Mateo with the Erasmus+project: Teaching with robots [18].
- The FIRST Lego League and WRO have begun being celebrated in The Canary Islands. In addition, this year - for the first time - the WRO is planned to be held in Gran Canaria, in the town of Gáldar.
- Teachers at participating schools have been motivated to design projects with their students in order to create small prototypes with electronic platforms like Arduino and Raspberry, creating project-based learning environments.
- The Faculty of Computer Engineering at the ULPGC, one of the associates, has experienced an increase in the level of enrollment after years of decline. Ciberlandia has been one of the initiatives included in the program to attract students [19].

6.2 Materials Generated

Over the years the team has been developing a series of educational contents that have allowed the successful execution and improvement of each of the phases and activities. Broadly speaking, we can classify the material generated into one of the following categories:

- Theoretical manual with basic introductory contents. As we discussed earlier, this material was previously distributed to the workshops for teachers at participating schools in order to prepare an eminently practical session.
- 3D design archive of robots to be worked on in the face-to-face sessions.
- Construction manual with the steps required to build the robot models presented.
- Presentations used in the classroom.
- Activity booklet.
- Evaluation test.
- Manual with the challenges set forth in The Grand Finals.
- Video Tutorials.

These resources are shared and made available to all participants involved. A range of resources generated by the organizers and the participants involved has been made freely available to the community [20].

7 Conclusions

Educational robotics helps to promote STEM careers among students and creates an interdisciplinary learning environment, which is able to contribute to the development of creativity, investigative thinking, logical reasoning and motor coordination. Despite all of these benefits, the lack of financial resources and the lack of qualified personnel make it virtually impossible to implement in many schools. With Ciberlandia, the importance of institutional and governmental support for introducing these new methodologies and tools into schools has been confirmed. This support should not be based solely on a provision or loan of material resources. The effort must be accompanied by experiences that allow for the training of teachers in the use of these tools and the encouragement needed to motivate and help them to implement these initiatives themselves. In the STEM fields, a direct channel of communication between the pre-university and university educational communities is essential so that there is continuity and meaning to the work that students develop from an early age.

Ciberlandia is a real technological experience in education, following a philosophy of project-based learning and with structured phases of initiation, progression and a final outcome. The student is driven to learn by the pressing need to find a solution to a project that is proposed. The project aims to be challenging yet entertaining in order to capture the imagination of students. They are already familiar with and fascinated by robots through video games, film, animation, literature,… but now, with Ciberlandia, they can gain practical experience by building and programming over the course of just a few hours their own robots by participating in an exciting project in which they become engineers, computer scientists, and even mathematicians.

We live with a strange paradox: science, technology, engineering and mathematics are areas which today hold little appeal for many youngsters. And yet it is obvious that these areas, which have revolutionized human civilization, are more present than ever in the lives of these young people themselves, to the point that they have become dependent on them. Almost all have a powerful computer in their pocket in the form of a smart phone; information and communications technology support their social networks and advanced forms of expression; domestic robotics has come into their homes through washing machines and “smart” refrigerators, and the streets are increasingly being invaded by autonomous vehicles that will soon be familiar. Although these youngsters are advanced users of these current and futuristic technologies, it remains largely unknown to them what is going on behind the scenes. They not seem to be aware of all the talent, effort and time that have gone into producing those devices, those applications, and those concepts. Perhaps because of ignorance - which leads to disinterest - or lack of confidence, they do not assimilate that which they seem to love with the realization that it can also be a way of life and an accomplishment for them. It is within their reach not only to understand, but also to improve and even revolutionize the technology which they are so passionate about. Scientific research, technological development and engineering progress continually need critically-thinking minds with new ideas and new concerns. Our society demands the same kind of professionals.

In the end, it is not a question of vocation, but rather of attitude. Having an inquisitive attitude; being autonomous, methodological, and even enthusiastic are common skills which are required at every level. There should be no boundary between primary and secondary school, college or university, or vocational training, and therefore these links must be created in order for students to transition between them naturally and with ease. Participants take their experiences with them to university, or from the university to the participating schools. It is explained to them the kind of work that is done at university, that university is useful to society, and that it is accessible and within their reach. The teachers also receive feedback from the university, and in turn they provide their own feedback to it.

Throughout these years, we have been able to ascertain the difficulties that school teachers face in attempting to carry out innovative educational projects and activities that depend on the acquisition of new material, both in terms of the economic investment required by schools and the need for teacher training courses which enhance implementation of new resources and adaptation to innovations in the curriculum. Given these circumstances, we have found that initiatives like Ciberlandia allow these types of tools and training to be brought to school for the benefit of teachers, as much as the students, helping them make effective use of available resources and establishing a starting point from which to work.

Finally note that during these years, Ciberlandia has been defined as its own brand, differentiating itself from other existing educational robotics competitions around the world [2–6]. The key to this differentiation is based on the following points:

- Workshops are offered directly by university researchers from the scientific/technical branch. Supported by various technological tools, they transfer and approximate classroom knowledge related to their daily work.
- Regarding the tools used in the classroom, the initiative is not linked to any particular commercial brand. In the development of activities in the classroom, the equipment is abstracted from the specifics of each line of business, focusing on the really important ideas and knowledge, and sharing this process of abstraction.
- It is an initiative that reaches all students in a school and not just a few. Students who enter the initiative do not have to pay a fee, which means that access to The Grand Final will depend on the work and effort put into the activities and not the economic resources available to each school.
- The robotic challenges to solve in The Grand Final are collaborative challenges between schools. This involves communication and joint work between the various teams. Also the challenges combine different technologies, allowing interaction between the physical and virtual environment through communication protocols, thus enriching the experience even more.
- Thanks to the format and the methodology followed, the materials are available at all times for all participants of the initiative from start to finish due to the rotating workshops. In this way each educational kit is exploited throughout the initiative by around 50 participants, making them great value for money.
- The development of the activities involve teachers from the various participating schools, which, although initially they had not proposed to participate and use these types of tools and teaching methodologies in the classroom, just by getting involved on their own initiative, their collaboration ends up making them one of the team.

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Creating New Learning Environment to Foster Enrollment in Engineering Programs

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Abstract. A discovery adventure! This is the program that has been developed by the Education Research Team of COPEC – Science and Education Research Council – a K12 School program for a city, with the goal of providing better and effective knowledge for young students, especially those who do not think about to enter a University. The main goal is to encourage more bright young minds to pursue careers in engineering or technology, by providing K12 students, from public schools of a municipality, knowledge about science and research methodology in a way that it will remain as a life practice. It fits into the counties' necessity to improve competitiveness in technology growth, which has implications in workforce development, as well as in science and technology development. The main characteristic of this project is the possibility to apply new and innovative approaches, which provide teenagers students the ability to develop concepts and theories to solve and understand scientific and nonscientific problems and, consequently, find solutions for those problems.

Keywords: K12 · Innovation · Science · Stem education · University access

1 Introduction

Despite the differences among cultures and peoples fortunately education is currently seen as the most desirable path principally for young people to earn a decent living and to reach personal growth and happiness. It is generally agreed that educated people not only get higher incomes but also contribute considerably to business innovation, productivity and national economic development. Recent evidence also indicates that educated people can make decisions that help to get healthier and longer lives. So, it is possible to say that education can help to get success, health and happiness. This is the desire of all human beings and no doubt that education is a great part to foster human

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welfare. Education has also a strong and direct relationship between investment in education, educational achievement and economic growth.

These facts show that it is necessary to work on improving the quality of basic education or K12, mainly concerning basic knowledge in literacy, numeracy and the development of the essential life skills. However, it is necessary to deliver a high-quality education with comparatively low spending. Therefore, public education, which should provide equal education access for all citizens, has to find ways to do so.

2 Current K12 Education Status

It is important to point out the importance of K12 education at present, since professional practices have changed tremendously and the requirements are not only very different from the previous professional generation, but they also keep changing, and quickly. It is imperative to develop means and ways to provide good quality K12 education, no matter what the economic level of the country is (Fig. 1).

Fig. 1. K12.

Although challenging, many countries are making efforts to change to a K12 system worldwide. Governments are seeking for new ways to enhance the quality of basic education and, in many places, a massive amount of financial resources are addressed to this. However, financial resources will not be enough if there is no actual project, which contributes to the improvement of the educational system in order to assure children's future, the development of advanced learning systems and the improvement of the country's academic curriculum.

One good aspect about the K12 system is that there is a spiral progression, this means that the simplest topics will be discussed initially, and will later on progress to more advanced or complex topics, helping students to cope up with all their subjects. In the future, there might be a better system, to provide better education, however, at the current time K12 is the one [1].

3 STEM Education

STEM stands for science, technology, engineering and math, and these are the skills that countries need now and in the future. However they are not always emphasized as well as they could by schools. These disciplines are widely considered to be the 'underpinnings' of innovation capacity (Fig. 2).

Fig. 2. STEM.

Apart from the discussions about the efficiency of STEM proposal, it is a way to overcome some gaps in education in order to enhance interest in technological professions, so necessary for the future of our society. What separates it from the traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. It teaches students computational thinking and focuses on the real world applications of problem solving. As mentioned before, STEM education begins while students are very young.

It has long been argued, based on income data, that university completion is the most relevant indicator of a countries' ability to produce highly talented, innovative people. Many studies show that the choice of the discipline matters to outcomes as well. Some researches show, for example, that people with university degrees in academic disciplines—such as the humanities, education, biology, and agriculture science—earn less than half of that earned by those with university degrees in vocational and applied disciplines—such as medicine, and engineering.

For every job advertisement for a bachelor's degree recipient in a non-STEM field there were 2.5 entry-level job advertisements for a bachelor's degree recipient in a STEM field.

What separates it from the traditional science and math education is the blended learning environment and showing students how the scientific method can be applied to everyday life. It teaches students computational thinking and focuses on the real world applications of problem solving [2].

4 Brazilian Education System

The Federal Constitution and the National Education Law determine the education system in Brazil. It is managed and organized separately by the various levels of the government and public administration:

- the federal government;
- the states;
- the federal district; and
- the municipalities.

Each of these levels is responsible for the educational sustainability, funding management and resource distribution.

The new constitution assigns 25% of the state budget and 18% of federal and municipal taxes to education [3].

Brazilian education is regulated by the federal government through the Ministry of Education, which defines the orienting principles of the organization of educational programs. The local governments are responsible for the establishment of state educational programs and follow the federal education guidelines, using funding provided by the federal government. Since 2006, mandatory schooling requires nine years (it was eight before), having as a key objective keeping the children at school for as long as possible, but, above all, to improve the quality of the initial training and literacy.

However education in Brazil is still a consigned right for everyone by the Constitution of 1988, which establishes that 'education is a right for all, a duty of the state and the families, and is to be promoted with the collaboration of society with the objective to develop citizenship and the participation of citizens in the workforce, working towards social benefits that all can benefit from' [4].

No matter the problems of the country, it is clear that education is somehow understood as a mean to guarantee a fairer society in one of the most unequal societies in the world.

5 STEM in the Country

The number of careers in Science, Technology, Engineering and Mathematics - STEM is on the rise. These jobs are vital to the economy of any country, both now and in the future, and Brazil is no exception. With the high growth rates that Brazil has demonstrated in recent times, the need for quality professionals in STEM fields is increasing. However, few of Brazilian students are adequately prepared to fill these important and lucrative positions. Part of the problem in question is the lack of qualified teachers in many public schools in the country, who also have to follow a theoretical and, in many ways, uninspiring curriculum.

However, there have been taken some initiatives in order to fulfill the gap. Many organizations have been working on training Brazilian educators in Physics, Chemistry, Biology and Mathematics using new methodologies such as those based on projects. Participant teachers, when acting, inspire public school students to attend college and pursue careers in STEM.

A study carried out by the Federal Council of Engineering, Architecture and Agronomy; CONFEA found that Brazil would require at least 20 thousand new engineers per year to keep up with the fast development of the economy and the industrial sector. However, the same Council acknowledged that this would be a minimum, and a much higher number of graduated engineers would need to be trained in the years to come. The Brazilian government, through several programs enabled the number of graduated engineers to increase. Still, the percentage of graduated engineers related to the total number of graduates decreased during this period from 7% to 6%, when in other countries such as China or South Korea, these figures are 35% and 25%. Also, in comparative terms, Brazil graduates about 23 thousand engineers per year, when in South Korea this number is 80 thousand, India, 200 thousand, and in China, 400 thousand.

In this context, the associations linked to the Brazilian industry are concerned with the fact that, according to the federal government, the Brazilian youth in STEM and engineering programs is waning, underlining that only 120 thousand vacancies are filled from the 302 thousand available at engineering schools (at tertiary education level) [5].

As part of these efforts the Education Research Team of COPEC – Science and Education Research Council - has designed and implemented the K12 School Adventure Plan for a city, whose challenge is to provide better and effective knowledge for young students, even for those who will not enter University, with emphasis in STEM subjects.

6 COPEC – Science and Education Research Council Research Team

COPEC – Science and Education Research Council is a multi-disciplinary organization that is a leader in advance science and its application to the development of technology serving society. It started its activities sixteen years ago and since then this organization has made a major contribution to the development of science and education, working to increase the best practices in several research fields.

Integration activities promoted by COPEC provide a qualified coordination and building partnerships because COPEC is an organization that brings together scientists who share the mission of promoting and developing science, technology and education.

The objectives of COPEC are to promote professionalism, integrity, competency, and education; foster research, improve practice and encourage collaboration in the different fields of sciences.

Contents, tools and services provided by COPEC, through programs, publications and consultations with national and international experts, contribute to the promotion of the professional who wants to be privy of the new achievements and services of man on technology.

COPEC enjoys respect and recognition internationally, characterized by the open discussion, the free exchange of ideas, respectful debate and a commitment to rigorous inquiry. Its IIE – International Institute of Education - is a bold and resilient source of innovation in higher education [6–8].

7 The Project

Countries have been challenged to get development and keep up the economical growth, no matter the crisis that they eventually are passing. Brazilian government is investing in sciences and technology development and education is a big part of it.

The Education Research Team of COPEC – Science and Education Research Council has designed and implemented a supplement K12 School program for a city, with the goal to provide better and effective knowledge for young students, especially those who will not enter a University. The chosen term ‘Adventure’ is because it is in fact an adventure through the sciences and technology world, by means of not only extra classes in science, technology, engineering, and math but also visits to interesting scientific and cultural sites.

The main goal is to help encourage more bright young minds to pursue careers in engineering and/or technology, by providing K12 students of public schools of a small city at the Atlantic Forest Region the necessary knowledge about sciences and research methodology which will remain as a life practice. It fits into the country's necessity to improve competitiveness in technology growth that has implications for the workforce development, as well as for science and technology development.

The program's main characteristic is the possibility to apply new and innovative approaches, which provide students the ability to develop concepts and theories to solve and understand scientific and nonscientific problems and, consequently, find solutions for those problems, too. It is a part-time program, delivered in two different moments during the day, in the morning and in the afternoon, always after the normal school period.

Students commute to the building that belongs to the City Hall, where they spend at least four hours having extra classes in the so called STEM - Science, Technology, Engineering and Mathematics fields with teachers especially hired to teach them. The program provides classrooms with multimedia resources and a class with computers for some activities, as well as visits to interesting sites are planned and delivered along the year. They also have visits to companies, museums, research centers, fairs, industries and other sites that can provide them a glimpse of a technological work atmosphere and the outcomes of these jobs.

Students are prepared to face the challenging process of university admission and even if they choose another path, or another career non-related with technology, or one that does not include university degree, they get the tools to face labor market too.

8 Teachers

Teachers are chemistry, computing, engineering and mathematics teachers (and/or university students) who volunteer to teach some hours per week in the program. Although they are volunteers, they get paid for their work, at least to cover transportation and food expenses.

They are integrated also as part of the organization committee in order to settle the schedule in a six months period suggesting visits and works based on tasks that challenge the student's imagination and the willing to solve problems, to look for knowledge and take actions.

The contact with the real work world and the invitation to participate in talks help them to have an idea that they are equally capable to overcome the adversities and to pursue a career involving, preferably, sciences, mathematics and technology even if it does not involve a university degree.

The program also counts with the participation of emeritus professors, who also volunteer to teach and, furthermore, some take part in the board of directors (Table 1).

Table 1. Schedule

School classes	Morning	Afternoon
Lunch time		
Project classes	Afternoon	Afternoon

Because of time constrains, every activity has to be developed within a reasonable distance in Km. This is why sometimes the best options are to invite lecturers to come to the students.

Every activity is scheduled on a time frame of 4 h, not exceeding these hours, including visits and invited lectures.

It is framed and balanced so that students can have a dynamic and interesting week of activities, avoiding routine.

The activities start in March and ends in October, stopping in July and followed by the winter break. There are seven months of intense and pertinent knowledge classes.

The activities follow an established organized schedule, in a way that both periods have visits on the same day or at least on the same week (Fig. 3).

Fig. 3. Schedule.

9 Some Details

As mentioned above, classes are scheduled in the morning and in the afternoon, once school hours are in the morning and in the afternoon.

The method starts with classes, which students have basic notions of scientific methodology in a language adapted to the students' age (as much as possible). STEM subjects, are combined with visits and lectures, which are followed by challenging problem-based classes to challenge the students to look for different ways to see and to solve problems.

Even the smallest detail of the classes are carefully examined and established, the disposal of the desks and the computer classes in different levels, besides the content in order to induce them to look at different options for their professional life, than what seems to be just arts, biology and letters.

Students have at their disposal a good equipped library, which was donated by some prominent people of the city, where students can go and look for extra information material.

There are always lecturers, even if they are only available for one period, another one will be invited to deliver the talk on the other period (Fig. 4).

The most important aspect is to provide the experience and contact with the professional and academic world, an immersion in scientific and cultural world in order to have a glimpse of the available opportunities.

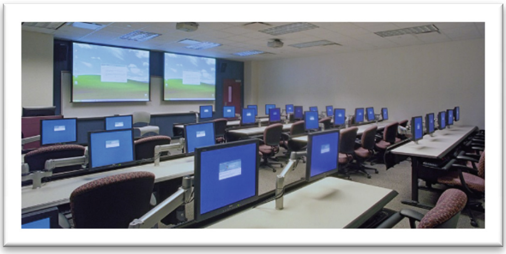

Fig. 4. Classroom.

The evaluation system is very smooth, since they just self-evaluate their performances and knowledge acquisition, they update their own portfolio with the goal to give them the responsibility of their personal growth. This aspect seems to be very important once they can see the differences of thinking and viewing themselves and the possibilities that are open for them too.

10 Conclusions

The main objective of this program is primarily to prepare the young generation of a community to face the challenging process of university admission and even if they choose another path, one that does not include university degree, they get the tools to face the challenging mutant labor market too.

The program also provides new teachers the possibility to apply new and innovative approaches to motivate the students to develop concepts and theories to solve and understand scientific and nonscientific problems and to find appropriate solutions.

The theoretical basis for this project is the Praxeology, the distinctive methodology of the earlier Austrian School of Economics, the liberal intellectual tradition of Ludwig von Mises (1881–1973) and Murray N. Rothbard (1926–1995) [7].

In 2014, university entry levels of public schools of the city have raised, what is a good sign that it is working and has contributed to the progress of k12 public school students' education continuity. However, it is not an indicator that the enrollment is specifically in STEM fields, once many of the chosen areas are still in human and biology sciences. Another aspect is that financial opportunities are bigger now, even with the economic crisis that the country is currently facing.

It is necessary one more year of activities in order to establish the real influence of the program in the enrollment of students in sciences and technology university programs.

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T-Learning: Proposal of an Innovative Pedagogical Approach on the Basis of Theatrical Techniques and Competition Spirit for Technical Modules Teaching

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Abstract. The greatest challenge of teachers today is to capture the attention of their audience in regard to the content being taught and avoid that they do other things during the classes; like using smart phones and social networks. Indeed, learners have different capacities of listening and the speed with which they approach tasks is not the same. That is why the learning methods are still getting improved in order to meet different learning capacities and ways to receive the information. On one hand, the learning strategies must meet the social, economic, technological, and cultural development. Then, the teacher should know how to make learners acquire information and transform it into knowledge. In this sense, the learning processes should be inspirational and revolutionary. On the other hand, it has been proven that classical courses where learners receive an extensive amount of information from the teacher is less efficient than the interactive way of teaching, where the learner takes part in the course and interacts with their fellow students and teacher. When the learner participates, discusses, and manipulates the information, the brain is more capable of long term memorization.

In this study, we suggest to work on the original learning method, based on theatre techniques and competition spirit, to improve students' outcomes in the management and technical domains in our private institute ESPRIT. The simulation results of this approach show that it is of a paramount importance.

Keywords: Industrial engineering · Recommendations · Illustrations · Media · Learning outcomes · Assessment

1 Introduction

Humanity has always sought to improve the knowledge and education has presented the only bridge for this improvement. In fact, this big challenge is the key for the nations' evolution all over the world. Indeed, nobody can deny that transmitting knowledge from one generation to another or particularly from a teacher to a student is an art that must be ordered by special rules. However, this issue has become more and more delicate because of external factors related to the environment of the learning

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process, such as the use of smart phones and social networks. Unfortunately, today this trend is leading to the failure of the current mode of learning and transmitting knowledge, especially when it comes to lectures and theoretical data. In fact, serious scientific research proves the more the human brain is stimulated, the more the acquired knowledge is easier to be stored in long-term memory. Indeed, several studies on the effectiveness of perception and memory modes were performed and showed the importance of action-oriented learning: speak, manipulate, and do. In this context, we are seeking for a creative and original solution that can coordinate between capturing the learners' attention during the course and satisfying the stages of skills' transmission. Therefore, we must combine between the playful side and the serious one.

To face this major problem, the universe of adults' training has evolved a lot and adapted innovative approaches.

2 Problematic and State of the Art

We start this section by identifying the various problems that prevent the learner from the proper assimilation of knowledge. Next, we will present a state of the art different teaching methodologies and their limitations.

Nowadays, we are facing another method of learning, in fact the experiments are enchained and we move from the affirmative method or lecture where we are obliged to learn what we acquire by heart, to the active method where learning stand on: experience, demonstration and theorization.

This active learning method is characterized by two aspects. First, we have to set the educational goals of the course. Second, we have to identify the learner's position in the educational goals already presented. During this method, the learners are positioned at the center of the learning process. In fact, they become guided by the curiosity as well as the willingness of self-training and self-learning which are raised by the use of concrete and tangible experiences. In this context, we introduce a Chinese proverb which reflects this idea: "I hear, and I forget. I see, and I remember. I do, and I understand." Learners actively participate in the acquisition and creation of knowledge, observe, reflect and contribute to a very large extent on the learner autonomy. In fact, learning is anchored by the experience.

Several problems persist despite the efforts made by teachers in their quest for improved learning methods:

- The students' lack of motivation: we notice a fairly large absenteeism, lack of enthusiasm and students' investment because of the heavy teaching methods (including lectures).
- The unrestricted access to information that can be, in many cases, inappropriate to build special knowledge or even erroneous. Students do not attend classes just because they have access to any information with just a single click. However, they do not question the reliability of online information.
- The reality is that with the invention of ICT in general and in particular Smart phones and tablets as well as the widespread use of social networks, young people become very obsessed by the use of these technologies, but unfortunately they are

misusing them. The use of these technologies leads to the learners' distraction and lack of concentration during the courses.

- Evaluation is a critical component of the learning process. It is the result made by the student after the learning process. The classic assessment revolves around the learner's acquisition of giving knowledge during the learning process, but this method of evaluation does not reflect the student's true level (possibility due to cheating during exams, luck etc.) or does not meet the objectives already set.

2.1 Summary Table

The summary table presented above unveils the lack of references dealing with the failure of the current mode of learning and transmitting knowledge. That is a starting point to emphasize our original approach. That is why presenting a new interactive mode of learning is indispensable (Table 1).

Table 1. State-of-the-art in the field of active learning

Issue / Reference	Inability of capturing the attention of the audience to the courses	Lack of interactive pedagogical approaches	Failure of the current mode of learning and transmitting knowledge (classical approaches)	Lack of experience, demonstration and evidence (lack of autonomy)	Modes of evaluation are not practical
(Alber and Heward, 2000)	*			*	
(Guthrie and Carlin, 2004)	*				
(Vanpee et al., 2008)	*	*		*	
(Garrison and Ehringhaus, 2013)					*
(Barrows, 1986)	*	*			
(Meignant, 1998)	*		*		
(Galand and Frenay, 2005)	*			*	

3 Our Approach

We start this section by giving a representative approach diagram then detailing each step to make the role of both teacher and student clear. First, and to make it more easy to get, we start by illustrating the approach by the following diagram (Fig. 1) that can perfectly represent our method's big line. Our approach is based on Deming wheel four steps that never stop in order to create a cycle. We affect n to a given stage (step) than increment 1 to the next one so that we create a continuous cycle.

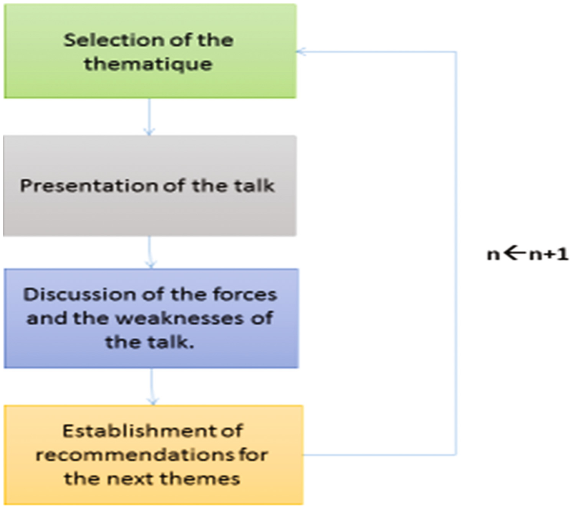


Fig. 1. The proposed approach

The Deming wheel is an illustration of the method of quality management said PDCA (Plan-Do-Check-Act), we manage to take these four steps as source of inspiration and the result was very practical:

- Plan:
  - Each group is invited to choose one theme from the module and imagine some ludic illustrations and storyline to explain it. First, the group establishes the objectives and processes necessary in order to deliver results in accordance with the expected output. Second, after tracing the main perspectives of the theme, the group examines its accuracy. The teacher invites each group to choose a theme belonging to the module and imagine some ludic illustrations and storyline to explain it.
- Do
  - Each group presents its talk: a system of rewards and penalties is defined for all groups. During this phase the group is invited to implement the plan and execute the process already traced in the first stage

- Check
  - The teacher and his students discuss the forces and the weaknesses of the talk. They compare the actual results which are studied in the "DO" phase with the results examined in the "PLAN" phase. By focusing on the differences concerning the results, choosing the appropriate plan for execution becomes an easy step.
- Act
  - The "ACT" charting data is based on collecting information. During this phase, if the group proves that the CHECK charting data shows that the PLAN executed in the DO phase reveals an improvement from the previous standard and consequently it becomes the current standard. But, if the CHECK charting data proves the contrary the current standard remains the same. In fact, the new charting data always brings about new methods of learning, alternatives and thinking.

The figure presented below simplify the matter: (Fig. 2)

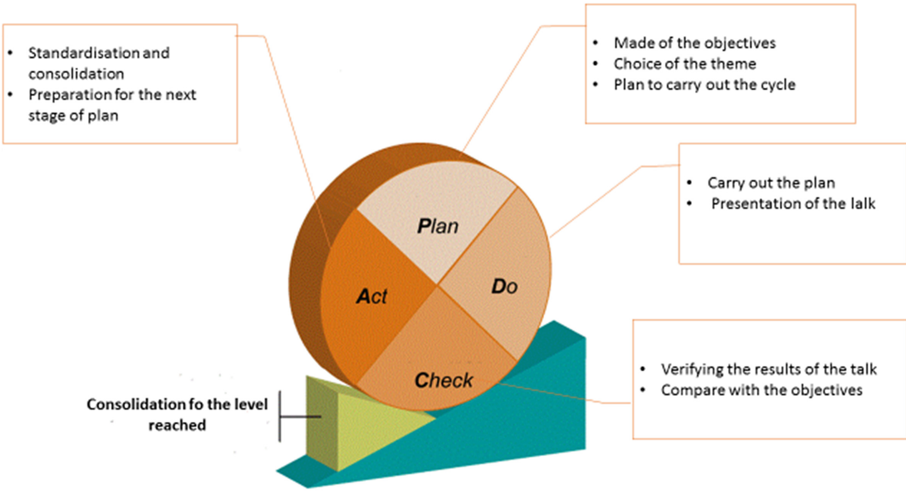


Fig. 2. The PDCA approach

4 Validations

For this experiment, we have resorted to multiple media since it is impossible to establish a real theatrical setting. We manage in a way that the class is divided into three groups. First of all and as it is mentioned in the explication of the approach, we make the objectives to reach. Indeed, each group will have a given learning outcomes which are illustrated by a real life situations in order to make it clear.

Then, we make students think about these situations by giving them playful question in order to push them to establish a sort of parallelism between the situation

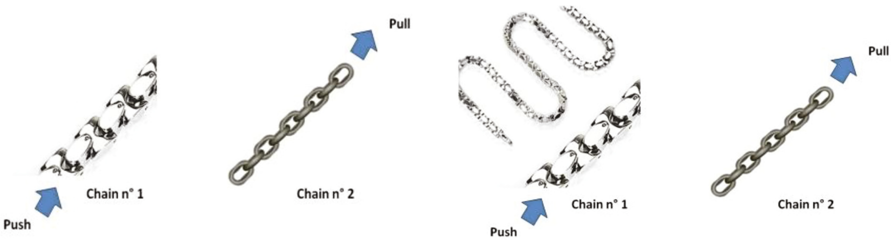
a : Group one b : Group two c : Group three

Fig. 3. Theatrical techniques used by the different groups

and the new information so that they can never forget it. The figures below illustrate the three groups (Fig. 3).

4.1 First Group

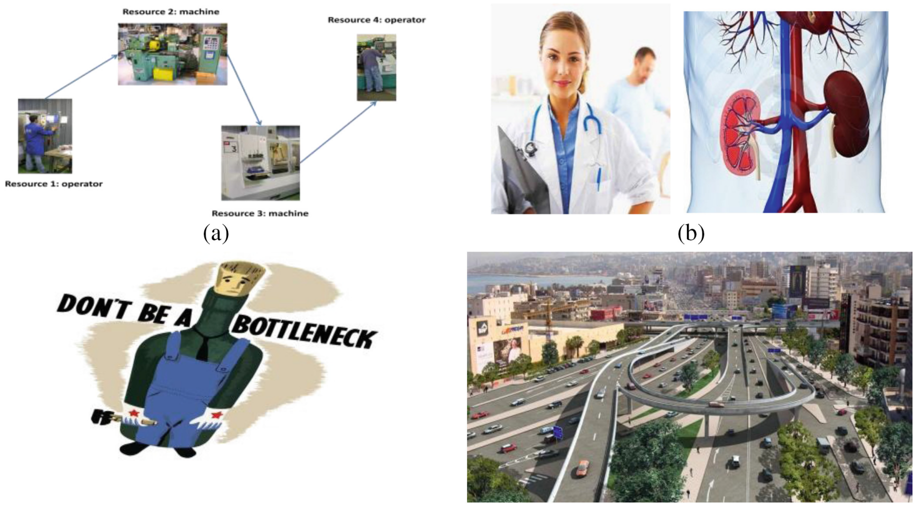
Learning outcomes: Understand and distinguish between pushed and pulled flow stream. Storyline 1: You have two metal chains on a table (chain 1 and chain 2). For the first chain you apply force to the first end (push) and for the second chain you will apply a force to the second end (pull, Fig. 4a & b).



(a) (b)

(c) (d)

Fig. 4. Ludic explanation of the difference between pull and push approaches



(a) (b)

(c) (d)

Fig. 5. Ludic explanation of the bottleneck constraint

Playful question: What form will each chain take?

Types of responses (Of course we have not quoted in this article all possible answers and there are several!):

- The second chain will remain tight!
- The first chain will wave!
- The first chain will fall from the table!
- The first chain becomes large while the second remains skinny, thin or lean!
- …

Storyline 2: You're in a restaurant and you have only empty glasses on your table. However, there is someone beside you who is sitting on another table on which there is a bottle of water and glasses.

Playful question: What are you going to do if you are thirsty?

Types of responses:

- Ask the person next to me to pass me the bottle!
- I signaled to the waiter to bring me water!
- I will make a complaint to the restaurant manager!
- …

Playful question: Is there a link between the example of the chain and that of the restaurant?

Types of responses:

- No! I see absolutely no connection between the two examples! Comparing two incomparable things!

- Yes! In the first case, the server pushes the bottle on the table while in the second case the customer pulls the consumption of water!
- The server and the consumer are two links in a chain which can be called supply chain!
- …

Speeches or conclusion: you just discovered by yourself the difference between a push flow and a pull flow systems in production. This example illustrates the difference between a classical approach (called Taylorism and Fordism) and a completely opposite approach called Toyotism (Just In Time philosophy).

4.2 Second Group

Learning outcomes: Understanding the bottleneck constraint. Storyline 1: Your manager sends you to visit a large international fair dedicated to robotics. He also tells you that there is a productivity problem relative to competitiveness. A production unit consists of two carriers and two machines. So, he asks you to acquire a powerful robot to replace an existing resource and provides you with the money for this acquisition.

Playful question: What resource are you going to discard?

Types of responses:

- The operator number 1 because he is in the beginning of the chain and he is very slow!
- The machine number 2 because it is very old!
- The operator number 2 because he is at the end of the chain and he is very slow!
- …

Storyline 2: A nephrologist must perform surgery on a patient to remove his/her failing kidney.

Playful question: From where should he/she start?

Types of responses:

- Skip to the operating room!
- Ask analysis, MRI, scanner, etc.
- …

Playful Question: What is the link between the occupation of an engineer and that of a nephrologist?

Types of responses:

- They did many studies!
- They both earn a lot of money!
- Before making a decision it is necessary to diagnose the situation through indicators!
- …

Storyline 3: You are driving your car and you are late because of a traffic jam.

Playful Question: What are the infrastructures that usually cause these jams?

Types of responses:

- Highways
- Bridges
- Roundabouts
- Tunnels
- …

Playful Question 4: Are there a similarity between the bridges, roundabouts and the slowest machine in a production system?

Types of responses:

- Yes! In both cases there is bottleneck (workflow of products and flow of cars)!
- No! Comparing two incomparable things!
- There are two different areas! There is no comparison!
- …

Speeches/conclusion: You have just found yourself an omnipresent constraint in industry: the bottleneck! So you have to buy a powerful robot that will replace the position slowest resource (machine or operator). And for that you need to diagnose your system because you may replace a resource that is not really a problem. In this case you will create an additional problem rather than solve it. As a nephrologist who will remove the non-defaulting kidney because he/she did not make the correct diagnosis.

4.3 Third Group

Storyline: A lost crow is found in the desert heat. It sees a half empty glass bottle. It should drink water otherwise it will die!

Playful question: How will it drink? Knowing that it has no straw and its beak does not have a plastic gasket! (Fig. 6)

Types of responses:

- It has no choice! It will die!
- It will throw inside small stones and by such the water level increases! This way, it can drink!
- It will tilt the bottle and drink!
- …

Playful question: Is there a link between the Kanban design system and this crow example?

Types of responses:

- There are crows on the factory roof!
- If the demand increases we must add Kanban cards, in case it decreases, we must withdraw! This is exactly what the crow does!

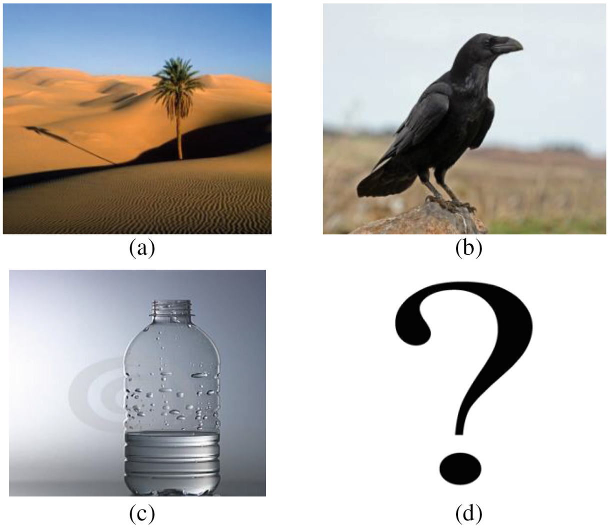


Fig. 6. Ludic explanation of the Kanban's sizing

- This example can be applied to a factory that manufactures glass water bottles!
- …

Speeches/conclusion: You have come to realize that the determination of the number of Kanban put into circulation depends mainly on the customer needs: if demand increases the number of Kanban increases accordingly, if it decreases the Kanban number must decrease too.

5 To Go a Little Further!

We announced to the students that we explained our approach to our fellow teachers (especially those teaching subjects such as 'hard and fast' (mathematics, mechanical), it follows, they were skeptical about the application of our approach in their subjects. From observation, a challenge was launched: ask all groups to try to prove the opposite and give them a week to do that. And the results of this challenge were simply spectacular. Here are the details:

- One group presented an example of mechanics: How to explain to students the degrees of freedom (a purely theoretical concept which calls for mathematical concepts such as torques, benchmarks, etc.). (Fig. 7)

(a) (b) (c)

Fig. 7. Ludic explanation of the degrees of freedom

- Step 1: Explain this concept with a playful approach with an illustration (Fig. 5):
  Question: What does your hand do?
  Answer: Prevent the hand from turning (rotate).
  Question: What is the board?
  Answer: Keep the stick from moving (translation).
  …
- Step 2: Explain this concept with a real illustration (Fig. 5):
  Cutting machine

- A second group presented a sample statistic: How to explain to students the significance of a normal distribution (Fig. 8, a) without using complex concepts (standard deviation, range)?

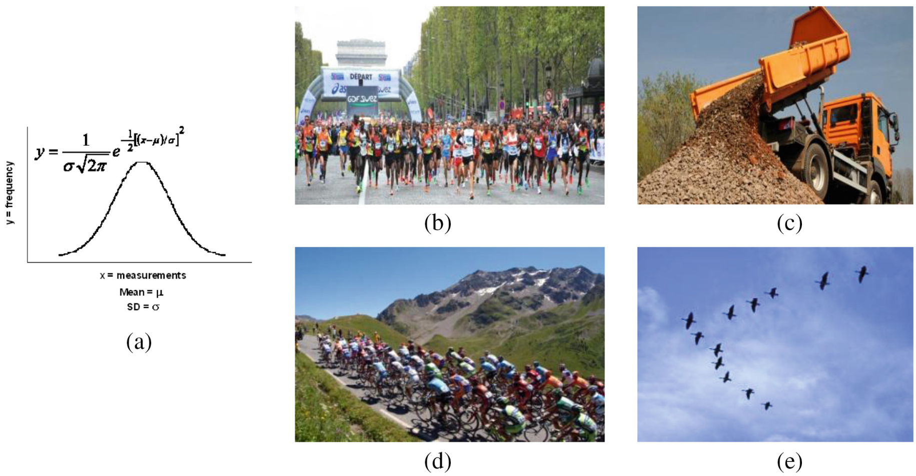


Fig. 8. Ludic explanation of the Normal distribution

- Step 1: Explain this concept with a playful approach by showing four illustrations (Fig. 8 (b, c, d & e)): Tour de France (aerial view), migratory birds in the sky, unloading a truck load of sand and Paris marathon (aerial view)):
  Question: What is the common point between these three illustrations?
  Answer: The shape taken by each phenomenon (bell).
  Question: Can we speak of dispersion?
  Answer: Yes! Individuals are distributed around a mean!
  …
- Step 2: Handle normal (In Excel for example):
  Varying the parameters (standard deviation, average, …)

• A third group presented an example of mathematics: How to explain the transpose of a matrix product? (Fig. 9)

$$(A * B)^T = B^T * A^T$$

(a) (b) (c) (d)

Fig. 9. Ludic explanation of the matrix's transpose

• I have a pair of tracksuit bottoms (matrix A) and sneakers (matrix B)
  - Question: In what order do you put them in the morning?
  - Answer: In the morning, I'll put my jogging pants first then sneakers: A * B.
  - Question: In what order do you remove them at night?
  - Answer: At night, I began to remove my sneakers $(B)^T$ then my jogging pants $(A)^T$
  - Conclusion
    $(A * B)^T = (B)^T * (A)^T$

Finally, we mention that this approach is a new method of learning and that it has not showed its execution yet in our institution, so we can not mention any statistic for this matter. This issue emphasizes this innovation in the field of transmitting knowledge.

6 Conclusions and Perspectives

Our work proposes an original pedagogical approach based on theatrical techniques for teaching technical modules. In fact, old teaching methods of learning such as lectures encourage passivity and permissiveness of learners and creates some dependence against the teacher and could also kill critical thinking in students.

The proposed model places the activity of the learner at the center of learning. Through this educational approach, we promote learning through trial and error. The introduction of this new teaching method, T-Learning tends to tickle the curiosity of students on a given topic and initiates creativity and innovation in their approach. Students would occupy a leading role in and an active position in their learning and the teacher becomes the companion of their learning. So the students are discussing the matter, learning to explain what they understood, considering different points of view, offering help and receiving support from other students. The T-learning offers learners the opportunity to work towards the content. This type of activity also allows them to better understand and develop a sense of belonging to the group and defend their views.

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Can MOOCs Support Secondary Education in Computer Science?

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Abstract. Despite the importance of competencies in computer science for participation in the digital transformation of nearly all sectors, there is still a lack of learning material and technically experienced teachers in German schools. In the paper at hand, we investigate the potential of Massive Open Online Courses (MOOCs) for secondary education. Schools can profit from this learning content and format provided by well-known institutions. However, German schools provide some challenging conditions, which have to be taken into account for a meaningful integration of e-learning elements. Our statistical and qualitative results are based on the representative data of the National Educational Panel Study (NEPS), the learning data of more than 100,000 online learners from over 150 countries, and the outcomes of several workshops with teachers and school administrators.

Keywords: MOOCs · STEM · K-12 · Flipped classrooms · Learning culture · Technical teacher training

1 Introduction

Digital literacy is recognized as a very important competence for participation in society and co-creation of digital transformation. Whereas, young people are treated as digital natives and computer science plays a minor role in secondary education. Often pupils are only learning how to use common computer software without understanding the underlying mechanisms or even how to use simple commands of programming by their own. Modern learning content is still seen as a competition to traditional ideals of education[1]. A reluctance towards new tools and technologies is inherent to school systems [1].

Innovative digital concepts of teaching and learning, such as Massive Open Online Courses (MOOCs) could help handling current challenges, such as large numbers of students with diverse educational backgrounds and rapidly developing technologies. MOOCs' uniqueness is characterized by the combination of offering educational content within a social media platform, enabling the course participants to learn within a virtual community, which has turned MOOCs into an attractive learning method [2]. Moreover, MOOCs are proclaimed as a tool to foster individualization [3].

[1] This, actually, is neither a revolutionary new insight, nor is it restricted to German schools. Back in the 1990's L. Cuban examined very similar phenomena in American schools.

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However, there are still some challenging conditions, which hinder the integration of e-learning elements in compulsory education.

2 Purpose and Goal

Our aim is to adapt the MOOC format for the requirements in schools. Thereby, we hope to be able to open the common learning culture in schools. Particularly in computer science, MOOCs can support secondary education as the schools are still lacking proper resources in this area. Related research is mostly focused on MOOCs in the field of tertiary education [4]. From our sociological and technological perspectives we investigate mainly on the following research question: Under which conditions can the adaption of MOOCs support secondary learning and teaching in computer science? We assume that MOOCs will be an attractive supplemental offer for pupils if some elements of MOOCs are suited to specific requests of schools. Concerning our MOOC "Learning to Program in a Playful Way" we will present the quantitative and qualitative results of learners who were younger than 20 years old in contrast to older learners by answering the following questions: Are there any specifics in regard to gender, participation in the forum, submitted exercises, learning curves, outcomes and dropouts? Are MOOCs for pupils more or less suitable than for adults or are they promising for both target groups? We will illustrate the potentials of IT enhanced learning as well as opportunities to get over certain barriers of computer assisted learning in schools. Therefore, we will discuss practical aspects of educational application of IT by using the example of the implementation of MOOCs in school contexts.

3 Literature Review

Related research ascertained that 98% of youth and young adults[2] in Germany are online. Being online can be considered as an important element of societal participation. However, pupils, whose families come from a high socio-economic background, are more confidential in using the Internet [5]. Compulsory education could support disadvantaged pupils and prevent widening the digital divide within society. By the age of 14 teenagers are using the Internet to a great extent independently. They are joining online communities early and use them intensively [5].

Technology in general and Internet technology in particular, attracts more and more attention in the educational sector [6]. In Germany, digital education is one of the key issues at the National IT Summit 2016[3].

The Internet offers the potential and challenge to transform the landscape of learning. By now the biggest effort of incorporating the Internet into education was expended in higher education. In General, older students are expected to be more capable to choose between different modes of study and to handle the worldwide web

[2] 14 to 24 years old.

[3] The IT summit is one of the main political instruments to implement the German Digital Agenda [7] – Germany's strategy to foster and shape digital transformation [8].

than children. "The Internet is not primarily an educational tool, but it self-evidently offers unique and unparalleled scope for the exploration of new forms of collaboration in the development and sharing of knowledge" [6].

Among many teachers the acceptance of online courses is still quite low. Good teachers are measured in regard to persuasive personality, responsibility to pupils, parents, management of the school and state authorities, individual teaching concept, high scope of interaction with pupils, well-founded knowledge of group dynamics, neutrality and objectivity. On the contrary in practical experience there is reduced possibility of individual work and environmental surroundings are very important for an effective teaching and learning culture. Teachers can only offer possibilities, while choice remains to pupils themselves [5]. Online settings and computer supported collaborative learning broaden this range and are a promising option for many pupils to gain access to appealing or gaming learning content [6].

4 Approach

We are analyzing representative data of the National Educational Panel Study (NEPS) concerning the current situation of computer science in German schools. Secondly, we have access to the learning data of more than 100,000 learners who participated in MOOCs about computer science provided by the online learning platform *openHPI* [9][4]. MOOCs are enforcing a defined schedule with learning materials, such as short videos[5], additional reading material, quizzes, homework and interactive as well as practical assignments. Learners are able to clarify questions and discuss further topics with each other and the teaching team via a social media platform. The four-week MOOC "Learning to Program in a Playful Way" is designed particularly for young people and was conducted twice (2014 and 2015) with more than 20,000 enrolments in total. Close to 6,000 course participants also took our additional surveys.

Furthermore, we have been conducting a modified version of this online course for two small groups of pupils in cooperation with two school teachers in the form of a so called Small Private Online Course (SPOC). In this setting, we have been experimenting with different use cases for the adaption of online courses in schools. Finally, we conducted four workshops in 2015 and 2016, discussing the possibilities of integrating MOOCs into schools with teachers and school administrators. These workshops were embedded in conferences of MINT-EC[6] and the German Informatics Society (GI)[7].

[4] HPI is subject to the Federal Data Protection Act, as the servers with the user data are situated in Germany. For platform improvement and research reasons, only anonymous data is used [9].

[5] 4-15 min.

[6] MINT-EC maintains a nationwide excellence network for German schools with a focus on Science, Technology, Engineering and Mathematics (STEM). Its declared goal is to offer outstanding learning programs for students and teachers in STEM. More than 200 schools with more than 20,000 teachers are integrated into this network [10].

[7] The GI and its 22,000 members worldwide offer a network to create early motivation and interest for informatics – supported by products to develop skills and aided by initiatives for training frameworks [11].

5 Collaborative Learning in MOOCs

openHPI-MOOCs feature a fixed start and end date and follow a weekly interval. Course participants have access to these learning materials at any time suitable for them, and as often as needed. However, all participants who are collecting points for a Record of Achievement, have to finish graded homework and exams in a timeframe defined by the teaching team. The format, hereby, allows a certain amount of flexibility for the participants, while providing a framework that enables the learners to feel the social presence of their fellow students.

Graded homework assignments are part of the requirements to receive a Record of Achievement. Additional assignments serve as practical or interactive tasks in which course participants can directly apply their recently acquired knowledge – e. g. coding assignments, which are embedded in *openHPI* via external tools, using the LTI interface [12–14] or the *Solution Through Execution Pattern* (STEAP) [15]. Another form of assessing these exercises are peer assessments, where participants grade each other's work. It can be used wherever automated grading is not possible or where the setup of assessments would be too time consuming. Another benefit is the requirement to reflect about the work of the peers [16] – and their own. The effort invested will pay off by improving one's understanding of the course material.

Learning experience is essentially enhanced by active participation in discussion fora. Interaction within the learning community contributes to the participants' learning process. Further features are offered, e. g. public or private *collab spaces* (learning groups). They are rather unique in the context of the large MOOC platforms and enable smaller groups to collaborate more intensively on special interest topics. They can be created by all course participants [17].

6 Outcomes

In the following subchapters we describe the current situation of computer science in schools, pupils' experiences of learning in MOOCs and teachers' and school administrators' attitudes to MOOCs in schools.

6.1 Current Situation of Computer Science in Secondary Education

German schools have two computer science teachers, on average. Usually, schools are equipped with 50 computers which provide an Internet connection, are at least two years old and located in computer pools. Access to computer labs "is dependent on internal power relations between different subject departments and teachers" [6]. Many teachers have little experience in using e-learning tools and do not feel comfortable with using technical equipment in schools because of their own uncertainty and the perceived unreliability of technology[8]. Representatively surveyed teachers ranked skills

[8] Another critical argument concerns the large amount of time pupils already spend by using technical equipment [18].

about computers and Internet on the third most important position of their own further education (see Fig. 1), behind educating students with specific learning needs and integrative lessons [19, 20].

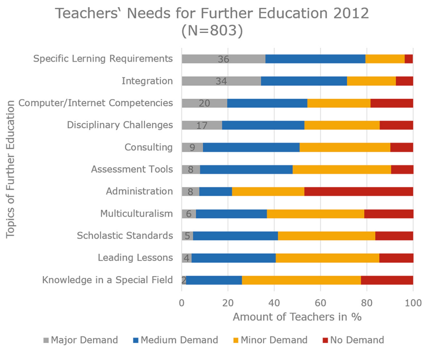

Fig. 1. Teachers' needs for further education 2012

6.2 Pupils' Experiences with MOOCs

In 2014 and 2015 more than 10,000 learners participated in the MOOC "Learning to Program in a Playful Way". In 2015 nearly 2,000 of the enrolled learners already had participated in the first iteration. 30% of all enrollments indicated their age. As it is shown in Fig. 2, in the first run of this MOOC, the amount of young students (year of birth 1995 or later) were significantly higher (23%) than in the rerun in 2015 (14%). Young students were less likely to rerun the MOOC than older learners. Among young students the amount of female learners was higher (23%) than among older students (< 20%).

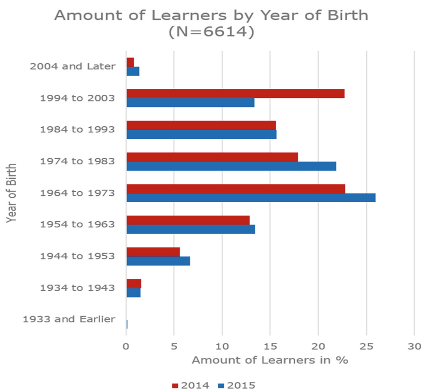

Fig. 2. Amount of learners by year of birth

With regard to participation in the forum, young learners participated more actively than older learners. Depending on the type of their posts, the amount of actively participating learners ranges from 12 to 17% among young students and from 5 to 8% among older learners. While young learners posted mostly questions, older learners more frequently posted answers. In both age groups comments on questions were posted least.

Concerning the course progress young learners reached significantly better results than older learners in all course weeks (27 to 32% better). Independent of age, the engagement declines during the course (see Fig. 3).

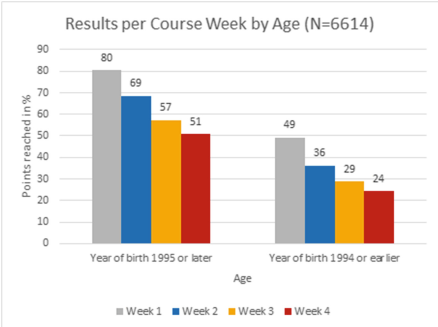

Fig. 3. Results per course week by age

More than 65% of the young learners earned a Conformation of Participation for accessing more than 50% of all learning materials, while more than 65% of the older students dropped out (p-value=0,2***). In average young learners are reaching more points than older learners. Differences in the motivation to complete the MOOC successfully may exist.

6.3 Teachers' and School Administrators' Point of View

Teachers and school administrators developed use cases for integrating (existing) MOOCs in schools in combination with necessary technical requirements provided by the MOOC-platform. They discussed the following potentials, challenges and framework conditions of MOOCs, in secondary education:

- Changing role of schools, teachers and teaching culture
- Technical equipment
- Legal issues and requirements

Schools are exposed to many changes and reformations, e. g. the transformation from teacher-centered teaching to autonomous learning. The importance of peer communication and mutual support increases. The role of teachers is changing from an instructor to a constant companion. Some teachers see their changing role as a threat to their profession. High-level innovations, such as learning platforms are far away from traditional teaching culture in schools. Apart from this it is a very promising approach to create “synergies between school learning practices and home learning practices” [6] by organizing learning activities in school in accordance with pupils’ learning in other contexts (e. g. information sharing, collaborative problem solving).

As many teachers criticize the availability and condition of technical equipment in schools innovative concepts are currently developed. The cloud technology is very promising for contemporary scholastic education in all subjects that can profit from a modern technological support. Via clouds pupils have comprehensive access to latest IT systems and e-learning programs, which are serviced professionally. This solution disengages teachers to maintain hardware. Schools only need display devices. Related computers run in a professional datacenter, which are connected to the devices in schools via Internet. From any workplace, pupils have access to individually equipped virtual machines via a remote desktop connection[9]. Altogether, the advantages of clouds concern flexibility, user friendliness, security, availability and cost efficiency. All stakeholders, particularly the teachers have to be consulted and listened to in depth[10]. Teachers have to be trained in the use of the infrastructure as well as the use of these tools. Teaching styles have to be reconsidered. E. g. the *One Laptop per Child* initiative has shown that technology in itself is not a solution [21]. Wherever the initiative can be considered successful it came along with a switch from an instructive to a constructivist teaching style. Wherever the technology was just mounted on top of existing structures, it ended in oblivion.

Some schools already use specific learning management systems (e.g. Moodle) and are not interested in using yet another e-learning-tool because of strict requirements to data privacy of their pupils. In this context the collection of pupils’ data by a third party is seen as critical as the monitoring of pupils’ learning behavior that can hinder exploratory learning because of anticipated negative assessment of not stringent learning activity.

6.4 Teachers’ Requirements for Using MOOCs in Schools

To conduct a MOOC in a school context teachers wish to be supported technically in the following aspects:

- “Batch registration” for the platform, a MOOC and collab space
- Consideration of curricula
- Didactically profound application
- Integration of MOOC-content into existing learning managements systems
- Provisions against cheating, undesirable content and cyber mobbing
- Insights into pupils’ learning progress

[9] A cloud provider should provide the infrastructure. Administration should be part of the responsibilities of either a government agency or a private company, which is commissioned by a government authority to take care of this task.

[10] Further necessary considerations are the learning materials and tools to be used with such an infrastructure.

The first challenges by using a MOOC in schools can already appear during pupils' registration processes. At *openHPI* a double opt-in registration is required[11]. If learners do not receive the confirmation email, they have to check their spam folder and can request a new confirmation email logging in with their access data previously selected[12]. If their account is already confirmed but they cannot log in, they have to make sure that JavaScript is enabled and cookies from our site are accepted. If it still does not work, they have to use the "Reset Password" function in the login form [9]. Plenty of things that can go wrong and might result in the loss of learning/teaching time. A so called "batch registration" is able to facilitate the registration process of several pupils without entering a proper email address, but registering all of them by the teachers' email account. In this context it is crucial to enable pupils to change their passwords by themselves[13]. In addition, it is important that pupils can later transfer their learning results into a regular account of their own for lifelong learning. After the registration at the platform pupils have to enroll into a certain MOOC, additionally they can join a collab space. This process should also be simplified.

Another big challenge for integrating MOOCs in schools is provided by the curricular requirements, which differ among countries, federal states and even schools. Today, computer science is not yet a compulsory subject and not bound to curricula in many federal states and inter-school discussions could be very inspiring [6]. Nevertheless, exercises have to cover the whole range of requirements. At the current state most MOOCs make use of multiple choice and multiple answer quizzes, which can be easily evaluated. More complex exercises are conducted in peer assessment. The majority of the teachers in the workshops agreed that peer assessment is an adequate technique for pupils starting from eighth grade. In addition to this many innovative exercises are provided in MOOCs, such as practical programming exercises with automatically assessed solutions and immediate feedback, which could be integrated in schools' existing learning management systems even without running a whole MOOC in class. Some other exercises in MOOCs could be replaced by those designed by teachers themselves. The majority of the teachers mentions the lack of didactical concepts as the major hindrance for the integration of online learning content into schools. Further interdisciplinary exchange between MOOC providers and teachers is required. A MOOC about "How to Use Educational Technology in a Meaningful Way" could help teachers.

For a promising integration of MOOCs in schools the content, period, time exposure, length and difficulty level in online sessions should be compatible to the lessons in schools. The amount and length of lessons, the performance level and range of performance differ widely between classes, so that a MOOC with synchronized learning periods and consistent learning content is not easy to incorporate into lessons.

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[11] To finish the registration process, the learners have to confirm their ownership of the provided email address by clicking on a link in an email that is sent to them by the system right after their registration.

[12] As long as their account is not confirmed, a message appears with a link to request a new confirmation email.

[13] While the teacher should not necessarily have the possibility to access the students' passwords, he/she needs the possibility to reset them for organizational reasons.

Instead of squeezing pupils into such a predefined structure teachers should be able to adjust deadlines for their students to a certain degree. An additional challenge is to design exercises for a massive audience in a way, which makes it difficult to just copy and paste the solutions of other students.

Online proctoring is one approach to guarantee that the registered pupil does the assignments by him- or herself. The learner's photo is taken during the registration process and during the assignments via webcam. These are compared by the means of face recognition algorithms by one of our partners. One of the photos taken during the registration process is then be placed on the pupils' certificate [9]. The drawback here is that this is a paid feature, which limits its usefulness in schools drastically. An easy alternative, however, is to have the students write their tests in class and have the proctoring being handled by the teachers.

Equal access to the exam questions is a prerequisite to use the results that have been achieved in the MOOC in the pupils' next school report. To enable this, the teachers requested exercises, which can be enabled exact to the minute when a lesson starts. Anyway, many schools have specific requirements concerning the recognition of achievements as relevant for the mark in a school subject. For that reason, some teachers would prefer their pupils to write tests about the course content, which have been designed by the teacher him- or herself.

A very important subject concerns the protection of young learners from undesirable content [6] and cyber mobbing[14]. On *openHPI* inappropriate behavior in the forum and collab spaces, such as insults, can be reported by other learners to the teaching team. Corresponding posts are deleted immediately and the authors are admonished per email to stop such comments. Participants are blocked if they repeat such negative behavior. On *openHPI* it happened only 2 or 3 times that a user had to be blocked. This, however, always happened in the MOOCs for school kids[15].

We conducted a sentiment analysis to determine the overall mood in the forum. For that purpose we integrated an open source sentiment analysis library in our discussion forum[16]. This library tokenizes the sentences of a post in the forum and assigns a numerical score to this token for its average sentiment. Finally, the sentiment of a post is determined by the overall score of the tokens. All scores smaller than -0.25 are considered negative, -0.25 to 0.25 are considered neutral and ever score greater than 0.25 is considered positive [22]. In the MOOC "Learning to Program in a Playful Way" from 2015 the posts are in average neutral (−0.25 in regard to the subsample of young learners and −0.21 among adult learners). The posts of young learners tend a little bit more into the negative direction than among older learners, but the difference is not significant.

Another feature that has been requested by many teachers, is a continuously updated overview about pupils' learning progress. It helps teachers to support and

[14] Related research indicated that, according to one third of young people in Germany who were surveyed representatively, mobbing is one of the major risks of using the Internet. 3% experienced mobbing already on their own [18].

[15] For reasons of child protection we did not promote the usage of Google Hangouts, e. g. for video calls, in those courses.

[16] https://github.com/7compass/sentimental.

assess pupils' achievements adequately. Some teachers, however stated, that there is a requirement for "gaps" in the monitoring of the students to provide them with a certain degree of liberty.

In theory, the communication in the forum could support teachers to follow and understand pupils' learning processes, difficulties and background discussions as well as "to manage and maintain the focus of attention and discourses within the classroom in ways that are not easy if individuals are privately engaged with their own trajectories of enquiry and interest" [6]. In our experiment, however, it turned out that the pupils did not use the forums at all. The main reason was that they were seeing each other every day and were able to communicate face to face directly. Another reason was that they prefer to use their standard tools of digital communication, such as *What's app* or *Facebook*. The willingness of teacher's, even if it is only suspected by the pupils, might actually be another reason why they prefer to use communication channels that teachers cannot access without the pupils' active permission[17].

6.5 Useful Scenarios for MOOCs in Secondary Education

MOOCs can already be quite useful for teachers and pupils in schools in regard to the following scenarios:

- Differentiation in regard to learning rates, educational trails and learning types
- Repetition, rework and homework
- Replacement lessons
- MOOCs developed by pupils and for pupils
- Blended learning setting

Teachers are confronted with many challenges, some of them exist already since a long time, and others more recently gained increased relevance. One of the current issues is the requirement to provide individual support, guidance and company for the different pupils. Differentiation is considered to be an efficient way to learn new things according to personal potential, pre-knowledge and individual learning behavior or strategies without being isolated. Nevertheless, in educational praxis the implementation of those ideals on the content, didactical, methodological, social and organizational level often entails challenges in regard to the lack of experience of teachers, missing learning materials etc. [23]. MOOCs could step in here, e. g. to match learning content to different learning rates. To offer diverse learning methods is fundamental for fostering education of diverse learners.

The potential of educational data mining and learning analytics in the meaning of measurement, collection, analysis and reporting of data about online learners in terms

[17] One of the authors has made a similar experience while teaching a face-to-face course at a University of Applied Sciences for several years. Even rewarding the students with bonus points for using a discussion forum in Moodle did not increase the activity in this forum. When asked why, the students replied that they preferred to discuss on Facebook as they could discuss there more freely without being under constant judgement of the teacher.

of understanding and optimizing learning and learning environments is currently a research topic of great interest[18].

MOOCs enable teachers to provide innovative, motivating, and challenging e-learning material for high achievers[19]. The possibility of anonymous learning and communication in MOOCs could encourage shy pupils to engage actively in the written discussion. MOOCs can be even suitable for pupils with specific learning demands, such as Asperger. Due to the large and increasing amount of MOOCs, teachers are even able to employ courses with different difficulty levels within one class.

MOOCs are already very helpful to repeat educational content, which was taught some month or even years ago and thus help stabilizing or improving this knowledge. They can further help to fill learning gaps in the case of missed classes and can complement regular lessons in regard to specific topics where external expertise is wanted. For many pupils MOOCs can be an attractive format for doing homework. Via social media tools pupils who e. g. get minor familial support can easily ask other pupils who can give advice immediately when a question appears or somebody stagnates in solving a specific task. Thus, MOOCs can "enhance the lines of communications between schools and home" [6]. In self-paced courses pupils can learn without any deadline. For that reason they can split their attendance in MOOCs to several replacement lessons during a school year.

A very interesting use case would be the development of a MOOC by pupils and for pupils. This learning methodology suits very well to interdisciplinary and independent learning. By creating their own MOOC pupils learn not only how to use such a platform. To a greater degree they learn how to apply MOOC-technology for their own purposes, including the generation of learning content, preparing presentations, video production and managing all steps in a team. At the HPI we have made several experiments in that direction. Currently we are working on a pilot project in which a 20-years-old student is conducting her own two-week MOOC about "How to Design My Own Web Page" [24]. The course is designed to appeal to pupils, especially girls[20]. In her MOOC the young teacher shares her knowledge about designing a homepage and wants to encourage young people to create their own web page. Prof. Dr. Johanna Wanka, Federal Minister of Education and Research, gave a video statement about this MOOC at the CeBIT Global Event for Digital Business in Hannover, Germany. She pointed out that digital media is an important gateway to the world of today and the future. Digital and media competence are central aspects of general knowledge. It is inevitable to master technology, not only to write emails [25]. Via a web page young people are able to create their own communicational offer. It is essential to make use of the opportunities of digitalization intensively and to participate via digital media. Smart

[18] Often, however, these learning analytics are still reduced to counting clicks on an e-learning resource. It requires great care not to misinterpret this data, e. g. defining active students by the amount of clicks.

[19] Additionally, e-learning is "enabling learners to take a more active role in their own learning" [6] in terms of autonomous and autodidactic learning.

[20] The young teacher is studying IT systems engineering and developed her first own web page at the age of 10 years.

girls and young women are encouraged to be confidential in regard to their technical capabilities [26].

We have previously conducted an experiment with some students at the HPI. In winter semester 2014/2015, we conducted an on-campus course with six students to design, implement, and conduct an introductory course on Java programming. Under scientific guidance of three PhD candidates, the students designed the learning materials and implemented practical programming tasks including unit tests to automatically evaluate the handed-in solutions of the course participants. The students also participated in recording the videos, always in team with one of the PhD candidates. Finally, some of the students also helped to supervise the course forums and the helpdesk. In terms of enrollment numbers and completion rate, the course was a big success[21]. However, it has to be stated, that a strict revision and quality control of the students' work is crucial for such an endeavor. During the next winter semester this course will be repeated.

A blended learning scenario is currently conducted in an experiment with a modified version of the MOOC "Learning to Program in a Playful Way". The following aspects are of prior interest for this paper: In corporation with two German teachers, two groups with ten 16-years-old pupils each take part in this MOOC. This unit of instruction is conducted during regular school lessons of 45 min and additional 45 min for homework per week. Taking part in this teaching unit is compulsory for the defined groups of pupils and they receive marks for their achievements in the MOOC. The modification concerns especially the transformation of the learning content from originally 4 to 12 weeks, because the workload was pretty high[22]. In addition some very difficult exercises were deleted and the course is not public, but only accessible for the defined pupils. Mainly, we are running two different use cases for the adaption of online courses to schools: One group watches the learning videos and does the first provided task in class while the other quizzes and homework are to be done at home. The pupils of the other group watch the videos at home and do the self-tests as well as other exercises in class ("inverted classroom")[23]. The experiment is still running, but we already can report the following findings and experiences: The integration of MOOCs into schools takes a certain time for preparation, e. g. in regard to pupils' consent, scheduling, signed consent forms by pupils' parents, the purchase of technical equipment, such as headphones and the instruction of pupils. Particularly in regard to the model of inverted classroom, pupils have to be instructed in using the platform and MOOC before the first lesson takes place so that they are able to watch the compulsory videos in time. One peculiarity, which contrasts our 4-year long experience with "regular" MOOCs is the lack of communication in the forum. We designed an intervention to increase the forum usage. Tasks were designed particularly for group work. Sharing ideas with classmates in the forum

[21] It featured about 11,000 participants, with a completion rate of about 33%. In the context of MOOCs, a completion rate of 33% is a very good result.

[22] In average the amount of work involved depends on one's prior knowledge and is estimated at 5 to 10 h per week. This involves working with the videos and the course material provided, checking one's understanding of the curriculum with self-tests, completing the homework and actively participating in the discussion fora [9].

[23] This learning mode was chosen to guarantee a comparable workload in both groups.

was encouraged and bonus points were offered for each meaningful post in the forum[24]. Interestingly, up to now the discussion forum is only used by the group, which watches the videos at home and does the exercises in class – "managed collaboration on the Internet does not necessarily lead to open dialogue, open knowledge sharing, or engaging co-construction of understanding" [6].

7 Discussion and Future Work

We are still at the beginning of applying e-learning, especially MOOCs, to secondary education. We will intensify cooperation with schools and initiate further pilot experiments in the field of e-learning, computer science and secondary education. In line with our experimental development of a MOOCs by young students we are planning to conduct a project work in schools where pupils are instructed to design their own MOOC.

(Anonymized) learning analytics are a promising research subject in which we will invest our resources expecting interesting results for improving e-learning for different groups of learners and educational settings. We develop assistive tools to support the learning process. A video-conferencing solution allows to connect learners to collaborate or discuss certain topics. First test runs within our programming courses yielded promising results. Not only allowed the face-to-face communication a more direct interaction in comparison to group discussions or written forum posts, but also were participants more likely to mention their own challenges in a private setting.

Another current issue, the necessity to create and improve suited (programming-) assignments, will be tackled by a platform currently developed to share, rate, and discuss material and task templates between instructors. Albeit the ongoing effort to develop so called Open Educational Resources, this has not yet reached widespread usage in the German school landscape. Particularly, with regard to programming exercises, the sole existence of suited tasks is not sufficient since they need to be technically integrated into the pupils working environment. In order to overcome this burden, our platform is intended to support the import and export of such tasks to program executing platforms via the standards LTI and ProFormA-XML [27].

Last but not least, we will broaden our research in regard to digital education beyond learning with MOOCs. Future visions about a cloud for lifelong learning include a centralized access to educational offers of different areas and levels. Features for orientation and transparency in the wide range of digital and on-site educational opportunities are planned as well as the integration of MOOCs as an important learning mode to open and socialize online courses[25].

[24] Comparable to grades or points for oral contribution in a traditional classroom setting.

[25] In Germany, such promising visions are still struggling with its fragmented and federalist organization of education.

8 Conclusions and Recommendations

To sum up, in secondary education computer science provides a certain need for the implementation of innovative e-learning concepts. MOOCs already provide attractive exercises for pupils with immediate feedback, e. g. practical programming, project based learning and peer assessment. It is attractive to use them in schools, too. The results of our analysis show that MOOCs are able to support secondary education by providing valuable content and learning styles. Many students took part in our MOOCs highly motivated and with a very good result. Recognizably, social interaction and collaboration are essential for successful participation in e-learning tasks. By using MOOCs in a well-designed teaching framework online courses are able to contribute to current challenges, such as differentiation.

By now, the first steps into the direction of a multidisciplinary cooperation between computer science and education are done. We identified a lot of starting points to implement MOOCs into the teaching and learning portfolio of schools. Nevertheless, many teachers are still skeptical to the integration of digital media and external learning content into their own lessons. Motivating reports and lessons learned of innovative projects are needed to serve as light-houses for e-learning in schools. We recommend further education for teachers and parents concerning the usage of new media in schools. For facilitating the integration of MOOCs in secondary education some framework conditions have to be taken into account, e. g. the changing role of schools and teachers, technical support, existing learning management systems and legal framework conditions in regard to students' data privacy. Moreover, the surveyed teachers require enrolment procedures for students without a proper email but via the teacher, detailed preview of exercises and insights about students' learning progress.

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Professional and General Education – Curricular Bridges Building

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Abstract. Been applied as successful motivation and preparation for technical studies and future engineering professions, innovations in general mathematics and natural sciences education with orientation to inquiry based learning (IBL) and its connection to the world of work (WoW) are described and discussed in the paper. This topic is worked out within the 7th Framework Programme of EU Mascil (Mathematics and Science in Life) project. Its main objective is (1) to develop complex tasks for teaching and learning practice in mathematics and natural sciences highlighting the world of work and (2) to provide teachers the methodology courses to increase their professional skills. The project feedback from the Czech teacher's environment is mostly positive, which provides chance to attract not only traditionally motivated teachers but also those expecting any outer motivation incentive.

Keywords: General and professional education · IBL · World of work · Wow · Teacher's professional education · Mascil project

1 Introduction

The current innovation of general mathematics and natural sciences education is strongly orientated to inquiry based learning (IBL) and its connection to the world of work (WoW). This approach can work as successful motivation and preparation for engineering studies and further choice of engineering professions. Development of both topics is supported by solving the international Mascil project (Mathematics and Science in Life) which also makes impact within the Czech Republic [1].

General Mathematics and Natural Sciences Education has had a long tradition in curricular systems but many times it used to be strongly oriented to ideal context. It means definitions, formulas, calculations and experimental activities were less connected to real life and also to engineering practice. The main purpose of the Mascil project is to develop complex tasks for teaching and learning practice in area of mathematics and natural sciences education strongly highlighting the world of work. A parallel purpose of the project is also to prepare a new concept of teacher's professional development where both the professional and general teachers can work and learn together.

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2 Approach and Methodology

The design of learning materials and content of teacher's professional development is based on the results of the school system analysis and the level of IBL and WoW in 13 countries participating in the project, i.e. on the analysis of current curricular documents and monitoring teacher's opinion by a set of questionnaires [2]. Results of these surveys are used for creating the complex tasks registered within the project which are available in the classroom-material database on the link http://www.mascil-project.eu/classroom-material, and also in so-called "Problems of Month" (PoM) developed by each national project team. The "Problems of Month" include various topics, e.g. House insulation; Parking Entrance; Forest and Timber Management; Design and Build Your Own Vacuum Cleaner, Hair Dryer or Toy Car; Do we know how much and what we eat?; Drug Concentration etc. Whole list of Problems of the Month published so far is in Table 1.

Table 1. Problems of month designed within Mascil project ordered by number of views [3]

Title of PoM	Supported professions	Published on Mascil Web	Number of views until May 2016	Authors country
Drug concentration How medication in blood changes over time	Chemical analysts in pharmacology	Feb 2016	563	Netherlands
Problem of hearing Design a simple hearing test	Audiologist	Dec 2014	519	Great Britain
Brine Make table salt of this brine	Chemical engineer	Oct 2014	507	Netherlands
Bicycle insurance Create an instruction for an insurance company	Insurance advisor	Nov 2014	506	Norway
Counting people How to write about a mass meeting in city	Journalist	Jan 2015	462	Spain
House insulation How to isolate a house	Building engineers and architects	Jun 2015	373	Cyprus
Healthy chicken = healthy egg? Are eggs of free-range hens healthier?	Scientific advisors for Public Health Information Service, or professions that requires a nutrient content such as this one.	Mar 2016	330	Norway

(*continued*)

Table 1. (*continued*)

Title of PoM	Supported professions	Published on Mascil Web	Number of views until May 2016	Authors country
Parking entrance Cars without damage on the ramp	Architects and Designers	May 2015	330	Bulgaria
Building a safe staircase Build a safe staircase for a private dwelling	Carpenters/joiners, builders, architects	Jan 2016	319	Great Britain
Forest and timber management Be an employee of a forest company	Employees of forest management companies and civil engineering companies, foresters	Mar 2015	291	Austria
IQ-game design Design an IQ game at different levels	Game designers	Sep 2015	260	Romania
Design and build vacuum cleaner, hair dryer or toy car Creative technical solutions	Electrical engineers, designers	Nov 2015	230	Turkey
Inventing a pipe clamp Produce your own pipe clamp	Mechanical engineer	Feb 2015	207	Germany
Regulating pH in fish-holding tanks Take care for a good pH	Fish hatchery supervisors	Apr 2015	199	Greek
Nesting box Building nesting boxes for endangered birds	Designers, woodworkers	Oct 2015	169	Lithuania
Do we know how much and what we eat? To know the energy of food	Food specialists, nutrition consultants, analytical chemists, biochemists	Dec 2015	120	Czech Republic
Routing school buses Finding an optimal route for school buses	Planners, mathematicians, transport managers	Apr 2016	117	Lithuania

Each month starting from October 2014 Mascil countries highlights one Problem of the Month, which is a carefully selected mathematics and/or science activity for teachers to try out with their students. The PoMs are purposefully selected, providing opportunities for teachers to trial out and work with inquiry based learning (IBL) activities in their classrooms with a problem closely related to the world of work and certain professions. For each PoM there is an online forum on the Mascil web page, where teachers may exchange their experience about working with this particular PoM.

3 Detected Outcomes

On the basis of developed and tested learning materials each national team prepared courses of teacher's professional development providing an occasion for professional competence development of both the general and professional school teachers [4].

The model of professional development (PD) in the Czech Republic, the same for teachers and multipliers (tutors of the courses) based on Mascil, was structured as follows:

- two face-to-face (F2F) meetings; the first one presenting main goals, structure and tasks, the second held one or two week later, dealing with participants′ final work based on presentation of own created or modified IBL task and experiences of its using in own classroom,
- selection of IBL task (from Mascil mainly Problems of Month, or from teacher's own database, or from other sources modified by user's own conditions) and its application to own learners in the classroom as base for final course work.

The three PD courses oriented to teachers on primary, lower and upper secondary schools were developed and accredited by the Czech Ministry of Education as courses of teacher's continuing education.

Following types of activities were included in the PD course content:

1. Principles of inquiry based learning (IBL) in school subjects mathematics and natural sciences in relations to current curricula and world of work (WoW).
2. Methods of IBL and WoW implementations in everyday classroom (on concerned level).
3. Levels of IBL and examples of their realisation in preparation, realisation and evaluation of teaching activities (on the concerned level) with orientation to professions.
4. Confirmation inquiry as the first level of IBL – teaching and learning process application (on the concerned level).
5. Structured inquiry as second level of IBL – teaching and learning process application (on the concerned level).
6. Guided inquiry as third level of IBL – teaching and learning process application (on the concerned level).
7. Open inquiry as highest level of IBL – teaching and learning process application (on the concerned level).
8. Using of ICT in mathematics and natural sciences IBL (on the concerned level).

This content was appropriately used also for pre-service teachers, mainly in the courses of Subject Didactics as an integral part of teacher study programmes in three semesters of M.A. level (13 weeks/semester, 90 min/week), where the design of IBL and WoW task related to the study specialization and analysis of learning situations are required for passing the exam.

From in-service teachers and multipliers, training of 8-h PD course (two F2F meetings, meetings with distance of 1–4 weeks), the design of IBL and WoW task related to the study specialization and analysis of learning situations are required for graduation from the course.

Participants' work on PD between F2F meetings was oriented on the self-development and own classroom teaching and on searching relation to professional world. From in-service teachers, their own teaching practice and preparation of self-reflection for F2F meetings were required. From multipliers, their own teaching practice, preparation of self-reflection for F2F meetings and the reflection of work with group of guided teachers were required. From pre-service teachers, on-going practice in teaching is applied in two semesters (13 weeks/semester), the design of IBL task related to the study specialization in own guided (i.e. supervised by teacher) practice and analysis of learning situations were required for passing the exam.

Outcomes of the Mascil project in the Czech Republic are highly evaluated by participants of teacher's PD courses as well as by informed Czech education community, not only in mathematics and natural sciences but also in pedagogical preparation of future engineers-educators. This fact was also detected during the policy makers meeting. In school practice, such a strategy is very helpful which does not prescribe compulsory subjects but educational areas on the level of Framework Educational Programme [5]. Within the educational areas schools can either use the traditional subjects, or create new subjects, blocks of lessons or other organizational forms of instruction. Reflecting the focus of the Mascil project, following areas were set: "Maths and its applications", which also includes the so called educational field Maths; and the educational area "Man and the Nature", which embraces educational fields Physics, Chemistry, Biology and Geography. Moreover, other educational areas closely relate: "Information and communication technology", "Man and the world of work", "Man and the Health" and the cross-curricular topic "Environmental education".

Another important point of view is the current problem of compatibility of the school reform and teacher preparation. Unfortunately, the new curricular approach has not been emphasized to a large extent. Traditionally, the Czech education system supports two-subject teacher preparation, in numerous cases freely combining Science and Humanities. Moreover, the teacher pre-service and in-service education in the Czech Republic is not provided solely by faculties of education but teachers for lower and upper secondary schools can also study at faculties of arts, science, maths-physics, technical faculties etc. Their approaches may sometimes differ from those of faculties of education, particularly in emphasizing the subject and underestimating the didactic preparation etc.

Within the fruitful discussion, following constraints were mentioned on implementation of IBL and WoW in curricular documents and pedagogical practice based on the Mascil project activities in the Czech Republic:

- unclear terminology and methodology, frequent misconception of IBL and project or problem instruction,
- incorrect understanding of the core of inquiry based instruction within the teaching staff (IBL is not a new method!),
- negative (rejecting) and distrustful approach to IBL from the reason of uncertain learning results,
- specifics of the IBL implementation in Maths and Science compared to other subjects,
- positives of the IBL implementation versus risks of no reached outcomes in Science subjects – it is the question of a radical reappraisal of expected educational outcomes in concrete subjects, key competences etc.,
- material demandingness of the preparation and application of IBL versus limited equipment of schools, the necessity of support from project sources.

From the analysis of discussions and interviews with engaged persons, following recommendations for Czech educational environment can be provided:

- to open the discussion on forming curricular materials which will more focus on educational processes than on concrete learning contents of subjects,
- to develop and financially support the system of further education of teachers in the field of IBL and WoW, it means to finish career system of professional development,
- to ensure stronger and concrete support for implementation of IBL and WoW in curricular documents, including renovation of textbooks and other study materials,
- to exploit the two-level curriculum for creating non-traditional school subjects with emphasis on IBL and WoW, both in general and vocational education,
- to innovate curricula of teacher study programmes towards higher level of application of IBL and WoW,
- to ensure the exchange of experience on the international level and various school levels.
- to initiate on given topics (IBL, WoW) discussions at concerned institutions and Maths and Science forums (e.g. Association of Czech Mathematicians and Physicians, Czech Chemical Society etc.).

The implementation of the Mascil project outcomes in the Czech Republic, particularly in teacher PD, brought supportive arguments for positive evaluation of the implementation of IBL and WoW; it can be summarized as follows:

- there exists a project whose results are directly applicable in teacher pre-service and in-service maths and science education,
- the application of IBL and WoW strongly relates to the personality and professional abilities of the teacher, as well as on the school and its climate,
- at lower secondary schools subjects are more isolated (in our opinion), they are no inter-relations, particularly in Science subjects, so that the IBL could be effectively implemented,
- IBL in the Czech Republic is currently a marginal approach only, but it starts expanding,
- most of Czech teachers still insist on memory based knowledge with learners, which is limiting for the IBL application,
- elements of IBL and WoW have not been included into the school evaluation criteria.

Reflecting all the above mentioned, we are aware a large extent of work is still in front of (all of) us. It is high time we started with the process of IBL and WoW implementation into the Maths and Science education on all levels of schools in the Czech Republic, as these approaches provide learners the connection (of our system of education) to the real world inclusive of engineers world, which we expect will enable them to succeed on the labour market in the future [6].

4 Conclusions

To find optimal relations and cooperation between general and professional education is a crucial point for all school systems, particularly the question how to increase learners' interest in engineering and technical (vocational) education. Everything should be conducted with deep attention to different objectives of both types of education. The learning content can be very close; however, in general education it is a means and in professional education it is means and also the goal of final educational outcomes.

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The Effect of Switching the Order of Experimental Teaching in the Study of Simple Gravity Pendulum - A Study with Junior High-School Learners

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Abstract. The present study focuses on the educational value of lab work while teaching and learning Physics. Specifically, it investigates and compares the learning outcomes between three different experimental groups, in the study of the Simple Gravity Pendulum in the lower secondary school, using a sample of 61 students aged 14–15. The first group comprising 25 students practiced first on virtual and then on real lab, while the second group of 24, first on real and then on virtual lab (change of order in the tasks). An additional third group, involving 12 students, used sensors and data loggers during experimental practice. The educationally optimum order of use of such labs is investigated herein. The learners exploited the capabilities of the lab equipment, in that they themselves designed, constructed, and analysed the simple gravity pendulum. The focus in the teaching and learning of the pendulum was on examining subject relevance in the context of everyday applications, the independency of the period from the mass of the bob, or the amplitude, and the dependence of the period from the pendulum length, and the local acceleration of gravity. The research tools used were a stabilised questionnaire, with 16 closed-type questions and 7 questions asking for a justifying answer, in addition to a semi-structured interview. Data were taken and were appropriately analysed and compared, and conclusions are presented herein. The results confirmed that concerning some teaching objectives, learners' understanding is positively affected by the order the real and the virtual labs are used in teaching. This result applies when addressing this age-group, and when teaching the simple gravity pendulum.

Keywords: Science teaching · Real experiments · Virtual experiments · Comparative study · Simple gravity pendulum · Lower secondary school

1 Introduction

Even though the study of the simple gravity pendulum is included in the majority of school curricula of physics worldwide, learners' perceptions about it are relatively poor [1]. According to literature reviews, research findings regarding students' perceptions

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and/or misconceptions about the apparatus and the associated observations, mainly fall into two categories. The first one is about research that relates to simple gravity pendulums, which students observe in a natural environment forming a mathematical model of a pendulum. In this category, it is the Newtonian conceptual framework that prevails, and students' perceptions refer to the period or frequency dependency of the simple gravity pendulum, the width of hovering, the weight of the bob, its length and their combinations [2–8]. The second category refers to the methodology used by researchers to examine the accuracy of the mathematical model regarding its ability to simulate and adequately describe the observed natural behaviour of the pendulum [4, 9–12]. It seems that students' misconceptions about the pendulum are significantly affected by their perceptions as regards their ability to recognise the variables and the checking of conditions [4]. Therefore, whatever change there may appear in the first one, should also include the second ones as well [10]. Finally, according to literature reviews, there is just one study that refers to students' cultural perceptions regarding the pendulum [7]. This fact demonstrates the acute mismatch between its profound role in physics [13–17] and science in general, and (on the other hand) its place in school curricula as a cultural feature [18]. During the past years, a large number of research effort on Science teaching has been reported. The main research topic seems to be the investigation of students' ideas (or misrepresentations), the study of students' reasoning and comprehension, and the methods proposed for overcoming any intellectual difficulties to conquest scientific thinking. One of the most important research results is the ascertainment that students use alternative models, with the help of which they mediate and try to comprehend all science phenomena and their every day applications. These so-called "alternative ideas", often remain unchanged or partly modified, even after many years of repeated teaching at a theoretical or experimental level, throughout formal education. To this end, to detect and confront them is of great interest to Science Education researchers, and especially so for such important physical phenomena, relevant for both Science and everyday life.

2 Rationale of the Present Study

Experiments play a dominant role in physics, and also in our attempt to understand the processes of physical phenomena in our world [19]. Studies have shown that school experiments affect and enhance knowledge acquisition more than traditional chalk-and-blackboard teaching. Teaching strategies incorporating experiments are considered the most important educational tools in the science classroom, especially when teaching difficult or abstract concepts [19]. Their role is to link theory with practice, especially for those students acquiring experimental skills, and enhance their exposure to scientific thinking and their consequently help their cognitive development. Experiments can be (a) real or (b) virtual or (c) performed with the use of sensors and data loggers.

Studies have shown that when experiments are appropriately designed, and engage learners in interaction and cooperation, they yield positive cognitive results. Moreover, research findings conducted between 1987 onwards, testing the educational use of real and virtual laboratories, have shown that the overall effect of such interventions was didactically similar when comparing real and virtual laboratories. Furthermore, combining both types was considered even more successful [20–22]. Keeping the aforementioned points in mind, and while appreciating the usefulness of both real and virtual labs in the teaching and learning process, it was decided to test the educational effect when switching the order the labs were performed, in class. What happens educationally when we first perform the virtual experiment and then the real one, and how does this compare with the opposite order of events, i.e. doing the real one first? Furthermore, when the experimental setup is enhanced by the use of sensors and data loggers, which is the optimum order to perform these experiments? Which educational planning yields the best educational effect? Which educational planning yields the best results? The validity of the present test is further enhanced by the similarity in the design of the real and the virtual lab exercises. Indeed, real and virtual labs are not only mutually compatible but also similar as, being designed in parallel, they form part of the very same unit of school-lab experiments. Systematic errors were further reduced in this study by the fact that the teaching was supervised by the same researcher in all 3 (broadly similar) experimental groups.

3 The Research

3.1 Research Question - The Sample

The main research question addressed here in was the investigation of the optimum teaching order. Which of the three – first the real and then the virtual lab, or first the virtual and then the real lab, or perhaps the use of sensors and data loggers- can better improve learning? Which method would yield the best results in the teaching of the basic concepts concerning the simple gravity pendulum? As such, we have identified and tested the following aspects: Relevance and everyday applications, independence of pendulum frequency from the mass of the bob, dependence from the pendulum length, the local acceleration of gravity, and the ever slight dependency of the natural frequency from the amplitude (i.e. the swing).

The sample consisted of three groups making a total of 61 Junior High School students, aged 14–15. Specifically, 25 learners worked on experiments progressing form virtual to real labs (group-1), another 24 learners with experiments starting from real and moving to virtual labs (group-2), and 12 more learners using sensors and data loggers (group-3). The learners exploited the capabilities of the lab equipment in order to design, create, and analyse the simple gravity pendulum.

3.2 The Research Tools

The study used both quantitative and qualitative research methods. The latter was used to provide the researchers with a clearer picture of any hitherto unsuspected educational research issues, via direct talk with the students, and utilised for research validation purposes. The research tool was a stabilised test with 16 closed-type questions of and 7 questions that asked a justifying answer, and in addition a semi-structured interview. The aforementioned test was verified regarding its validity and reliability during a pilot-phase testing. The teaching objectives of the specific questionnaire used are presented grouped in various categories, in Table 1 below:

Table 1. Categories of teaching objectives for the subject taught

Categories of teaching objectives for subject taught	Question number	Teaching objectives
O1. Relevance & everyday applications of simple pendulum	1, 2, 3, 4	To understand the usefulness and everyday applications of simple pendulum
O2. Dependency of period on the pendulum length	7, 14	To understand the relationship between period and pendulum length
O3. Independency of period on the mass of the bob	5, 9, 11, 15	To understand the relationship between period and mass of the bob
O4. Dependency of period on local acceleration of gravity	12, 13, 16	To understand the relationship between length and the local acceleration of gravity
O5. Independency of period from the amplitude	6, 8	To understand the relationship between period and amplitude of the swing

3.3 The Purpose of the Research

The purpose of the present study is to investigate the educational effect when switching the teaching-order when using virtual and real labs, as well as when experimenting with sensors and data loggers, while studying the simple gravity pendulum. More particularly, the aim was to investigate the extent to which a different order in the use of labs (i.e. first virtual and then real, versus using first the real and then the virtual lab) gives the best results in terms of conceptual understanding of the basic concepts concerning the simple gravity pendulum on 14–15 year-olds. An additional aim concerns the question of whether any progress of conceptual understanding differs when students practice on real laboratory using sensors and ICT, albeit combined with adequate theoretical explanation. For this purpose, a comparative study was conducted between different orderings (time-wise) of lab-type usage, in order to determine the effectiveness of switching the order of Lab-teaching, using whichever method.

3.4 Research Stages

The research took place in three successive phases of 6 teaching hours, with an additional fourth phase of one hour (conducted after a month) used in order to detect any late changes of learners' ideas, regarding the simple gravity pendulum.

Particularly, during the first phase (1 h), learners' alternative ideas were detected with a test (pre-test), which was appropriately adapted from that directed to older students, to the learner's level of comprehension. The second phase (4 h) started with learners' familiarisation with the lab equipment to be used, and some general information provided to the learners concerning the subject of simple gravity pendulum. The basic instructive tool used was a worksheet following the principles of inquiry-based learning, containing all activities to be completed, and the instructions to be followed so as learners shifted from virtual to real labs or vice versa, or alternatively used sensors and data loggers. During the third and last 1-h phase of the research (conducted three weeks later), learners a post-test (which was the same text as the pre-test) in order to detect any changes in their initial ideas regarding gravity pendulums.

Analytically:

- 1st phase of intervention (1-h): The students of the three groups were given a questionnaire to answer (as a pre-test) with the help of which their preliminary ideas regarding the subject taught were recorded. Interviews and discussions followed, to probe students' opinions and ideas, truly latent to them as they often are, and consequently obscured from us as they lamentably often remain.
- 2nd phase of intervention (4-h): The second phase started with learners' familiarisation with the lab equipment to be used, while providing some preliminary information concerning gravity pendulums.
- 3rd phase of intervention (1-h): Semi-conducted interviews, and open discussions were conducted. This was done to probe even further students' (hopefully improved) opinions and ideas, albeit still rather latent to them as they might remain. Subliminally presented stimuli were often used to that effect, as a means of communication.
- 4th phase of intervention (1-h): Three weeks after the conclusion of the aforementioned teaching, the same learners were asked to complete the same initial questionnaire, so as to detect any permanent change in their ideas regarding the simple gravity pendulum.

4 Results

4.1 Method of Processing the Experimental Data

In the present study, the broadest possible definition of the term "assessment" is adopted (i.e. estimating, testing, measuring, rating). Specifically, assessment is "the process of evaluating the effectiveness of a particular sequence of instructional activities when the sequence is completed" [23]. This can be achieved, as aforementioned, with a proper tool that allows the classification of what is being assessed in at least two hierarchical levels, focusing on the variable of interest, despite the numerical expression of the result. The numerical expression of the result from a diagnostic test may well lead to the illusion of accuracy and objectivity of the evaluation. But no one is ever able to assure us that every question of a perfectly balanced and objective test has exactly the same value and the same importance as the others.

4.2 Statistical Analysis - Data Analysis

The use of the appropriate checking criterion (parametric or not) between research hypotheses depends mainly on the plan of the research, the commitment of the level of data, and the type of the indices of the measurement of the variables. To analyse the data obtained presently, the IBM-SPSS statistical package was used, and an ANOVA-test for independent and a t-test criterion for dependent samples were performed. For the purpose of the present study, the level of significance was set at 5%. The research hypotheses are:

- H0: Null hypothesis: The participant groups of learners display the same performance after the teaching intervention.
- H1: Alternative hypothesis: The participant groups of learners have display different performances between them, after the teaching intervention.

It should be noted that, in H1, there is no intrinsic attempt to predict which group displays the best or worst performance. Therefore, a two-sided checking of hypotheses is formulated. The results are presented below.

4.3 Discussion of the Results

It is reminded that the participant groups were three, group G1 consisting of 25 learners working from virtual to real environment, group G2 comprising 24 students working from real to virtual environment, while a further 12 learners used sensors and data loggers (G3). The comparison process of the three groups' performance entails four basic stages of checking. (a) Checking per group and between groups, regarding pre and post instructive aim O1. (b) As above but for aim O2. (c) As above but now for aim O3. (d) As above but for aim O4. (e) Checking per group and between groups in the pre and post instructive as above but concerning aim O5, and (f) Checking per group and between groups as regards their total performance.

Checking groups G1, G2 and G3 before the teaching intervention (Pre – testing) for all individual teaching objectives.

The following (Table 2) represents the ANOVA – test of independent samples.

This is based on the ANOVA-test, obtained for all individual teaching objectives which correspond to a (pre-determined) non-significant statistical ($p > 0.05$) result. This leads to the acceptance of the null hypothesis, meaning that the performance of learners in group G1 does not differ from that of the learners in group G2, or those in group G3 before the teaching intervention ($\mu_{01TOTAL} = \mu_{02TOTAL} = \mu_{03TOTAL}$), for each individual teaching objective. One can therefore proceed with the rest of the comparisons.

We can reach the same conclusion using a chart (error chart1) with the intervals of confidence set at 95% of the mean of each group's performance (Fig. 1).

From the above diagrams, one can deduce that there is no statistically significant difference between groups at the pre- test stage, as the corresponding overlaps are larger than half of the mean error margin. This means that, since the two groups were indistinguishable, all further testing is valid.

Checking groups G1, G2 and G3 after the teaching intervention (Post – testing) for all individual teaching objectives.

The following (Table 3) represents the ANOVA – test of independent samples

Table 2. Results of ANOVA-test for independent samples at PRE-Testing level for all individual teaching objectives

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
Usefulness - Applications Pre-test	Between groups	430.857	2	215.429	.425	.656
	Within groups	29405.208	58	506.986		
	Total	29836.066	60			
T vs. L Pre-test	Between groups	956.216	2	478.108	.321	.727
	Within groups	86420.833	58	1490.014		
	Total	87377.049	60			
T vs. W Pre-test	Between groups	513.508	2	256.754	.450	.640
	Within groups	33113.542	58	570.923		
	Total	33627.049	60			
T vs. g Pre-test	Between groups	771.870	2	385.935	.382	.684
	Within groups	58574.108	58	1009.898		
	Total	59345.978	60			
T vs. θ Pre-test	Between groups	1020.082	2	510.041	.483	.620
	Within groups	61275.000	58	1056.466		
	Total	62295.082	60			

After the intervention the results of the post-test revealed that the learners who started with the real lab and continued with the virtual one achieved better results (78.12% ± 10.42%) than either those who began with the virtual and continued with the real laboratory activities (71.75% ± 9.73%) or those that dealt with the sensors and the data loggers (64.06% ± 14.62%) (Table 4).

The ANOVA-test shows significant statistical results [(F(2.60) = 6.607, p = 0.003]. This result indicates that this differentiation should be investigated further to determine between which experimental groups this occurred (Table 5).

The results showed that there is a statistically significant difference between the groups, and the use of the criterion Tukey HSD (Post-Hoc Multiple Comparisons) showed that the statistically significant difference is to be found between the groups G2 (Real –> Virtual) and G3 (Sensors and Data Loggers) [MD(I-J) = 14.06, p = 0.002)]) (Tables 6 and 7).

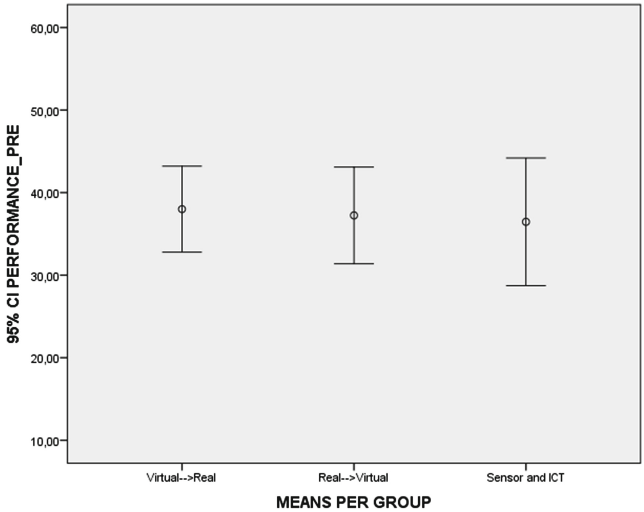

Fig. 1. Error chart for the participant groups in the research at pre-test

Table 3. The table with the descriptive indexes of the dependent variable (performance) at the three conditions of the independent variable at post-testing stage

Descriptive				
Performance_Post-Test				
	N	Mean	Std. Deviation	Std. Error
G1: Virtual –> Real	25	71.75	9.73	1.94
G2: Real –> Virtual	24	78.12	10.42	2.12
G3: Sensor and ICT	12	64.06	14.62	4.22
Total	61	72.74	12.07	1.54

Table 4. The overall table of the variance at post-testing

ANOVA					
Performance_Post-Test					
	Sum of squares	df	Mean square	F	Sig.
Between groups*	**1624.046**	**2**	**812.023**	**6.607**	**.003**
Within groups	7128.516	58	122.905		
Total	8752.561	60			

Further statistical analysis using the ANOVA-test of the results, showed a statistically significant difference at the instructive goal concerning the relation between period and the mass of the bob, i.e. [(F(2.60) = 5.231, p = 0.008] between the groups. The use Tukey HSD criterion showed that there is statistical significance between groups G2 (Real –> Virtual) and G1 (Virtual –> Real), i.e. [MD(I-J) = 14.41, p = 0.041)] and also between G1 with G3 (Sensors and Data Loggers), i.e. [MD(I-J) = 20.83, p = 0.014)]). This allows one to assume that the subsequent use of real lab first

Table 5. Table multiple comparisons for the dependent variable Performance Post-Test the results of applying the criterion Tukey HSD to the three conditions of the independent variable

Multiple comparisons				
Dependent variable: Performance_Post-Test				
Tukey's Honest Significant Difference (HSD) test				
(I) Means per group	(J) Means per group	Mean difference (I-J)	Std. Error	Sig.
G1: Virtual –> Real	Real –> Virtual	−6.37500	3.16817	.118
	Sensor and ICT	7.68750	3.89337	.128
G2: Real –> Virtual	Virtual – >Real	6.37500	3.16817	.118
	Sensor and ICT	**14.06250**[a]	**3.91959**	**.002**
G3: Sensor and ICT	Virtual – >Real	−7.68750	3.89337	.128
	Real –> Virtual	**−14.06250**[a]	**3.91959**	**.002**

[a]The mean difference is significant at the 0.05 level.

Table 6. Results of ANOVA-test for independent samples at POST-Testing for all individual teaching objectives

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
Usefulness – Applications Post-test	Between groups	1054.457	2	527.228	1.632	.204
	Within groups	18740.625	58	323.114		
	Total	19795.082	60			
T vs. L Post-test	Between groups	2528.415	2	1264.208	1.339	.270
	Within Groups	54766.667	58	944.253		
	Total	57295.082	60			
T vs. W Post-test	**Between groups**	**4296.004**	**2**	**2148.002**	**5.231**	**.008**
	Within groups	**23818.750**	**58**	**410.668**		
	Total	**28114.754**	**60**			
T vs. g Post-test	Between groups	768.993	2	384.497	.524	.595
	Within groups	42549.649	58	733.615		
	Total	43318.642	60			
T vs. θ Post-test	Between groups	608.197	2	304.098	.276	.760
	Within groups	63900.000	58	1101.724		
	Total	64508.197	60			

Table 7. Table multiple comparisons for the dependent variable Performance Post-Test the results of applying the criterion Tukey HSD, for all individual teaching objectives

Multiple comparisons					
Tukey's Honest Significant Difference (HSD) test					
Dependent variable	(I) Means per group	(J) Means per group	Mean difference (I-J)	Std. Error	Sig.
Usefulness - Applications Post-test	Virtual –> Real	Real –> Virtual	−3.29167	5.13689	.798
		Sensor and ICT	8.16667	6.31275	.404
	Real –> Virtual	Virtual –> Real	3.29167	5.13689	.798
		Sensor and ICT	11.45833	6.35526	.178
	Sensor and ICT	Virtual –> Real	−8.16667	6.31275	.404
		Real –> Virtual	−11.45833	6.35526	.178
T vs. L Post-test	Virtual –> Real	Real –> Virtual	−1.00000	8.78146	.993
		Sensor and ICT	15.66667	10.79156	.322
	Real –> Virtual	Virtual –> Real	1.00000	8.78146	.993
		Sensor and ICT	16.66667	10.86424	.283
	Sensor and ICT	Virtual –> Real	−15.66667	10.79156	.322
		Real –> Virtual	−16.66667	10.86424	.283
T vs. W Post-test	**Virtual –> Real**	**Real –> Virtual**	**−14.41667**[a]	**5.79119**	**.041**
		Sensor and ICT	6.41667	7.11682	.641
	Real –> Virtual	**Virtual –> Real**	**14.41667**[a]	**5.79119**	**.041**
		Sensor and ICT	**20.83333**[a]	**7.16474**	**.014**
	Sensor and ICT	Virtual –> Real	−6.41667	7.11682	.641
		Real –> Virtual	**−20.83333**[a]	**7.16474**	**.014**

(*continued*)

Table 7. (*continued*)

Multiple comparisons					
Tukey's Honest Significant Difference (HSD) test					
T vs. g Post-test	Virtual –> Real	Real –> Virtual	−4.16697	7.74028	.853
		Sensor and ICT	5.55637	9.51205	.829
	Real –> Virtual	Virtual –> Real	4.16697	7.74028	.853
		Sensor and ICT	9.72333	9.57611	.570
	Sensor and ICT	Virtual –> Real	−5.55637	9.51205	.829
		Real –> Virtual	−9.72333	9.57611	.570
T vs. θ Post-test	Virtual –> Real	Real –> Virtual	−-4.66667	9.48547	.875
		Sensor and ICT	3.66667	11.65673	.947
	Real –> Virtual	Virtual –> Real	4.66667	9.48547	.875
		Sensor and ICT	8.33333	11.73523	.759
	Sensor and ICT	Virtual –> Real	−3.66667	11.65673	.947
		Real –> Virtual	−8.33333	11.73523	.759

[a]The mean difference is significant at the 0.05 level.

to virtual laboratory later has improved learning of the specific subject taught, and for this specific age group, when compared to either the group that worked in the reverse order of lab activities, or the one that used sensors and data loggers (Fig. 2).

From the above chart, one can support the view that there is a statistically significant difference between groups at post-test stage, as the corresponding overlaps are not bigger than half the mean of the average marginal error. This holds true except for instructive aim O3 (i.e. Independency of period from the mass of the bob) where there are overlaps are bigger than half the mean marginal error.

All this allows one to assume that the subsequent use of real lab first and virtual laboratory later leads to improved learning of the specific subject taught, always for this particular age group. This is in comparison to both the group that worked in the reverse order of lab activities, or from group G3 that used sensors and data loggers.

It is worth mentioning however, that during the informal discussions with the learners, their excitement and enthusiasm was clearly apparent for the total procedure. Reasons given included the ability to switch from one type of lab to the other with relative ease, given that everything was provided for in the mobile-lab environment.

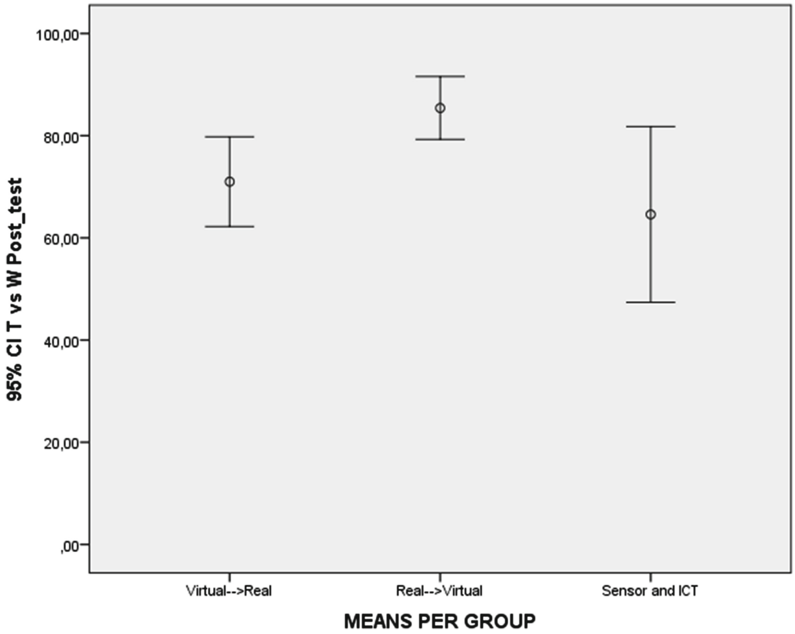

Fig. 2. Error chart for the participant groups in the research at post–test

As both types of lab were included in it and they did look similar to each other, no time was wasted in shifting from the one to the other type.

5 Conclusions/Recommendations/Summary

The results of this research effort have shown that selecting to experiment in the order of "real lab first to virtual lab later" has a better effect on learning, than when selecting the opposite experimentation order, when learning the behaviour of simple gravity pendulum. It also offers clearly better learning outcomes than when the exercise involved sensors and data loggers. It would appear that, somehow, the greater abstraction offered by the suitably designed, virtual laboratory acts as a halfway step towards the formal abstraction, represented by the ultimate goal – the theoretical understanding.

Measurements have also confirmed that learners can use the lab equipment to work on both real and virtual lab somehow in parallel, and utilising simulations, and real-lab equipment, and sensors and data loggers to enhance learners' conceptual development, thus making it an appropriate and contemporary tool for the teaching of pendulums.

Furthermore, the results of the study revealed that the cyclical process of virtual to real or alternatively from real to virtual lab maintained learners' interest (in that it did not seem to be a straight repetition), enhancing their critical thinking and improving the learning process.

There is also an apparent need to expand the present research for the optimum order of real and virtual labs use in teaching, and investigate the relative merits of either strategy when teaching other Physics subjects. It is the expressed intention of the authors to persevere in this research direction.

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Model of Network Interaction for Involvement of Children and Youth into Scientific and Engineering Creativity (Through the Example of Tomsk Regional Children Non-Governmental Organization "Hobbycenter" Practice)

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Abstract. The lack of high quality engineering professionals are widely spread problem. Formation of such specialist should start from the very early stages of education with involvement of children and youth into scientific and engineering creativity. Tomsk Regional Children Non-Governmental Organization "Hobby-center" has developed a model of network interaction for increasing efficiency of this processes. The model was approbated in small number of Tomsk schools and one university, then scaled to involve most of Tomsk educational institutions. it is being replicating in other regions of Russian Federation in frameworks of program "Center of professional competences for involvement of children and youth into scientific and engineering creativity".

Keywords: Engineering education · Scientific and engineering creativity · Inventive activity · Active and interactive methods · NGO

1 Introduction

The modern world needs engineering professionals that are able to meet the challenges of the new age, to innovate and create new engineering ideas. To grow such professionals we need to start from the very the initial stage of education. It allows raising engineering and inventive mind in children. This concept is not equally successfully implemented in different regions of the world. The problem with involving children and youth into engineering education is particularly relevant in Russian Federation, because of fundamental changes in educational system (e.g. implementation of three-tier high education, new Federal state educational standards). An extensive system of engineering personnel training, including at the earliest stages of education, existed previously: technical creativity clubs, magazines "Young technician", "Technology of Youth",

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"The inventor-innovator" in all enterprises existed departments of R&D, or at least some people responsible for the level of invention and rationalization, technical universities and research institutes had their own patent department. The mechanism of involving into technical creativity on every level (in accordance with LLL concept) is only in the process of formation. Tomsk Regional Children Non-Governmental Organization "Hobbycenter" (NGO "Hobby-center") has developed a model of network interaction for involvement of children and youth into scientific and engineering creativity. The model was successfully approbated in Tomsk region. Nowadays it is being replicating in other regions of Russian Federation in frameworks of program "Center of professional competences for involvement of children and youth into scientific and engineering creativity". The model will be described in the following paper.

2 Model of Network Interaction for Involvement of Children and Youth into Scientific and Engineering Creativity

The model of network interaction is presented on the Fig. 1

The acting subjects of the model of network interaction for involvement of children and youth into scientific and engineering creativity are:

- Socially-oriented non-governmental organizations
- (SO NGO);

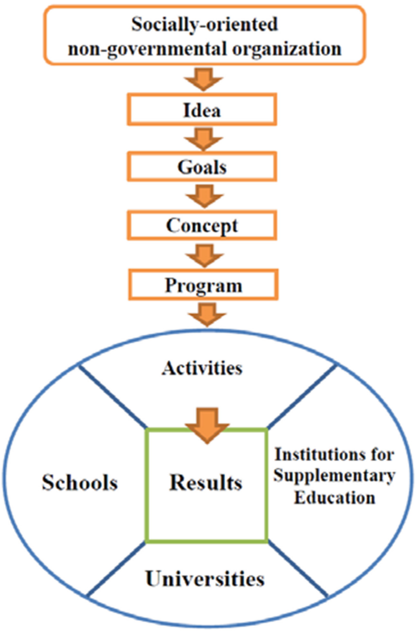

Fig. 1. The model of network interaction for involvement of children and youth into scientific and engineering creativity

- Universities
- Schools
- Institutions for Supplementary Education

SO NGO detect a problem in society and education. It is a difference, delta between desired situation and existing situation. NGO creates an idea how to solve the problem, it sets the goals, so that reaching them will improve the situation. A concept should be developed on basic of the idea and the goals. Then the program is developed for reaching the goals. The program is a list of activities that should be presented in certain periods. Execution of the program leads to the result. According to the model universities (or other higher education institutions), schools, institutions for supplementary education are taking part in actions as co-organizers or participants. Also the results of the program realization are positive for every participant of the model.

If we would imagine the presented model as a mechanism, SO NGO would be an engine that make all the parts moving and working. It is actually initiate the whole process, because NGO is more flexible organization (in compare with university or school), its activities do not regulated by strict governmental standards and rules. NGO is able to respond more quickly to changes, introduce innovations. Such innovations are leading educational methods, gamification of educational process, project-based learning, problem-oriented learning, interactive technologies in education [1–3]. Non-governmental organizations can approbate such methods and then share their best practices with other educational institutions. Also the NGO main objective may be exactly involvement of children and youth into scientific and engineering creativity. As for universities and schools, they have their own objectives, different from popularization of engineering creativity. NGO can focus on solving this problem.

3 Realisation of the Model of Network Interaction for Involvement of Children and Youth into Scientific and Engineering Creativity in Tomsk Regional Children Non-Governmental Organization “Hobby-Center” Practice

TRC NGO “Hobby center” started working on the problem of involving children and youth into scientific and engineering creativity in 2009. Science that time number of projects were carried out (Table 1).

TRC NGO “Hobby center” chosen project form of realization of the model for involvement of children and youth into scientific and engineering creativity. First projects involved 7-25 local schools and one university (Tomsk polytechnic university). In the year 2014 it started to scale the model to the whole Tomsk region. The model of Hobby-center practice is presented on Fig. 2.

In frameworks of Hobby-center activities more than 200 innovative technical projects were brought to life by teams of students (school and university) [5–8]. Among them:

- Interactive sandbox (sandbox that projects different pictures depending on form that a child gives to sand)
- Touch lock (electronic lock that is opened by fingerprint)
- Vetrosvet (equipment of playground with wind turbines to provide illumination in non-electrified areas)
- Smart Meal Shall (lunch box that can independently heat the food after SMS direction)

Table 1. Projects of TRC NGO "Hobby center"

Year	Name	Results
2014–2016	"Center of professional competences for involvement of children and youth into scientific and engineering creativity"	Replication of the model of involvement of children and youth into scientific and engineering creativity to 6 regions of RF. Organization of trainings for SO NGO, consulting and methodological support
2014–2015	Stimul -2	Approbation of developed model for involving youth into innovative and inventive activities in Tomsk region
2014–2015	School academy "Learning is fun"	Organization of championships in game form PIFAGOR.RU (mathematics), TESLA BOOM@TOMSK (phisics) GenerationIT@TOMSK (IT), trainings for teachers and gaming lessons
2014–2015	Resource center of gamification of educational process	Creation of resource center of gamification of educational process in Tomsk region
2014	Involving youth into innovative and inventive activities	Involving youth into innovative and inventive activities through organization of development real innovative projects by school and university students
2014	Tomsk – territory of gamification	Teachers from 7 Tomsk schools were trained to develop and conduct gaming lessons
2013–2014	Stimul	The model of project-based learning for children and youth was developed
2012–2013	Polygon of innovative approach -2	Project teams were created in 25 Tomsk schools. The mechanism of interdepartmental interaction was developed
2010–2011	Polygon of innovative approach -1	
2009–2010	Science academy for schoolchildren and youth "Synergy"	Database of children talented in engineering field was created

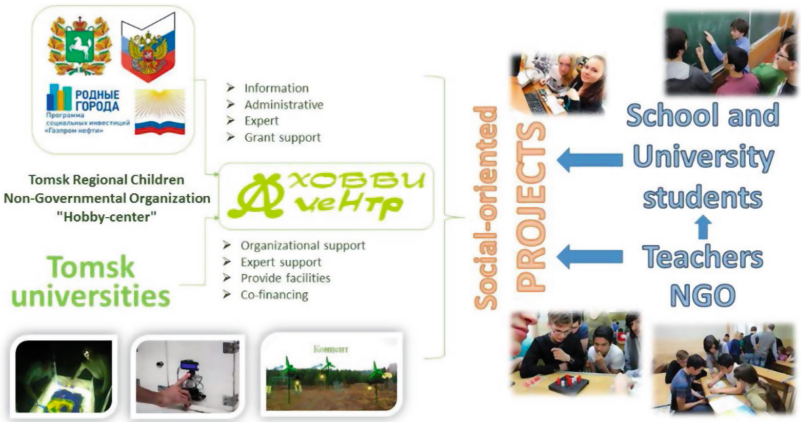

Fig. 2. Realization of the the model of network interaction for involvement of children and youth into scientific and engineering creativity by TRC NGO "Hobby-center"

4 Replication of the Model in Other Regions

In the end of 2014 TRC NGO "Hobby-center" started replication of developed and approbated model of network interaction for involvement of children and youth into scientific and engineering creativity in frameworks of the program "Center of professional competences for involvement of children and youth into scientific and engineering creativity". It was supported by Ministry of Economic Development. After comparative analysis of best practices the following methods were chosen:

- Trainings on relevant subjects in different cities
- Case studies (events aimed at attraction to scientific and engineering creativities on which example representatives of NGOs can learn how to develop and organize the events)
- Consulting
- Development of teaching materials

Over 150 representatives of NGOs from 4 regions have already participated in the program. 10 teaching materials are developed and provided in the open access.

5 Conclusion

The model described in the paper has proved its efficiency. Its implementation produce synergy effect. Involvement of children and youth into scientific and engineering creativity by interacting network of universities, schools and institutions for supplementary education initiated by social-oriented nongovernmental organizations is more successful, then individual actions of each organization. The model was developed and approbated in Russian Federation, but it can be implemented in other regions of the world. It will help to attract talented children and youth to engineering professions. As competences of highly qualified engineer will start developing earlier, it will increase the hole level of technical specialists in the world [9–13].

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Learning Culture, Diversity and Ethics

Technical Student Electronic Cheating on Examination

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Abstract. The study is designed to gauge the forms, frequency and variety of electronic cheating of technical university students, and their attitudes toward various behaviors when taking an examination, as well as teacher attitudes toward cheating as perceived by students. The results are based on two samples - 102 engineering students and 98 engineering pedagogy students indicate that respondents felt quite liberal in their views of potential cheating when there were no effective preventive methods of course teachers. Attitudes toward cheating depended on what students saw and heard, on their personal qualities, teacher personality and policies enacted by institutional culture related to academic integrity.

Keywords: Engineering students · Technical university · Electronic cheating · Moral integrity · Prevention

1 Introduction

Cheating is a general negative phenomenon most people unfortunately face in their everyday life. Scholastic cheating can be observed in different types of schools and its quiet tolerance is in contrast with their educational role. Academic integrity has been a persistent issue in higher education. The problem of tertiary students cheating is widespread and many believe it is even endemic [4].

Statistical data on the extent of dishonesty and cheating vary widely, most probably because of differences in methodology. First large-scale study of non-electronic cheating in academic institutions was published in 1964. It surveyed over 5,000 students from different colleges and universities and found that 75% of respondents engaged in incidents of academic cheating [6].

More recently, it has been found that as many as 50 to 75% of students admit to cheating during their academic careers. In addition to this, 50 to 70% of faculty members (e.g., teachers) report that they have observed cheating [8]. These rates are consistent in both public and private education, with neither being more prevalent over the other [7]. Recent reports attest to the undeniable fact that the degree of cheating at the university level is alarming. Already more than twenty years ago, some authors [5] found that 67% students reported at least one incidence of cheating. Reference [7] found inappropriate cut and paste infraction in 25% of their sample in 2004, but some studies even reported that 80% of undergraduates in Australia admitted to cheating

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academically in the same year [4]. Another reason for this trend is not that the students are becoming more dishonest, but that the integration and use of technology in tertiary education are presenting students with new opportunities to cheat.

2 Conceptual Framework + Current Research

Student cheating has been researched from different views, including psychological ones. In order to find motivation to cheat in broader aspects some basic concepts were put into relation with unethical behavior:

(a) Moral integrity

Good character can be understood as a family of morally valued, positive traits of personality, which are relatively stable and generalizable across different situations, but which are not necessarily fixed or rooted in immutable genetic features [3]. These characteristics can be connected with an opposite what we understand cheating. Integrity (authenticity, fairness) is a psychological quality of being honest and having strong moral principles, moral uprightness. It is generally a personal choice to uphold oneself to consistent moral and ethical standards.

(b) Scholastic Cheating

We can define scholastic cheating as a transgression against moral integrity which entails taking an unfair advantage that results in a mispresentation of a student's ability and grasp of knowledge. This includes obtaining inappropriate assistance from other person or from an online source or adjutant, plagiarism, and false self-representation [2].

(c) Academic dishonesty

Academic dishonesty can be characterized as academic fraud. With this characteristics we can even see relevance to the business term fraud triangle as formulated by [8]. The fraud triangle depicts three elements present when fraud occurs. These three elements are incentive pressure, opportunity and rationalization attitude. Transferred into academic conditions incentive/pressure relates to good grading, opportunity manifests itself in an environment when "nobody is watching" and rationalization/attitude becomes prevalent and "excusable" when students believe other students cheat too [9]. All three elements that make up the fraud triangle are potentially present in the examination environment.

According some research results variety and diversity of electronic cheating has been constantly growing [4] and its most frequent are introduced in [10, 11]:

- copying information from a mobile phone, flashdisk, diary, laptop - from the proper student or class-fellow
- dishonest test acquisition (print-screen) from a class-fellow
- seminar work plagiarized from the Internet or written by another person
- passing an exam for another person while misusing his/her system password
- mutual help over discuss groups during the test
- cracking teacher's computer to gain the test

Based on the results of our previous study [2] and some other resources [1] we would like to suggest 3 major groups of factors that might have impact on student cheating - some of them will be treated in our new research:

- University and its social climate:

People are significantly influenced by their social environment. University climate represents social environment which influences students for several years. Size of the university and anonymity of its environment, university specialization (technology, sciences, humanities), existence of university moral integrity policy, sanctions for dishonest students, technological equipment + reference to technology usage, study requirements, teacher workload, level of teaching quality control – these are factors which might contribute to prevalent student his/her value system and behavior.

- Teacher personality (human qualities, intellectual qualities, pedagogical, presentation and organization skills):

Teaching enthusiasm, intellectual curiosity, intellectual flexibility, ICT skills, carefulness and consistency of teaching activities, teacher's subjective (over) estimation of his/her subject (course), ability to provide good explanation, justice, quality of assessment procedure, keeping the tests up-to-date, preventive measures during exams.

- Student personality:

Age, teacher/university/study program/student relationship, intellectual capabilities, study success, motive of achievement, preference of deep learning style, moral integrity, temperament structure, mental health.

3 Research Target, Questions, Methods, Research Sample

This paper reports on two studies, one which investigates the cheating practices of transportation engineering students (n = 102) and their attitudes toward cheating [1], and the other which investigates the same problems in the sample of engineering pedagogy students, the study program which is based mostly on humanities (n = 98). All respondents were pre-graduate students of a technical university with a long tradition (founded in 1703). The studies also intended to identify particular problems students face in their learning and give insights into situations which can lead to poor learning practices and, in the worst cases, to cheating.

Our survey was aimed in both groups at these issues:

- specification of cheating forms
- frequency of student cheating
- subjective "justification" of dishonest behavior
- teacher attitudes toward cheating as perceived by students.

Based on queries used in our prior research on academic integrity [2, 3] and our experience in psychology courses teaching, a 15 item questionnaire was constructed for our purpose. The queries reflected issues potentially related to dishonest behaviors, and reference to technology usage when taking an examination. For some items, a 5 point

Likert-type scale was the response format used, for few items 7 point Likert-type scale was used with one extra open-ended response. The survey form requested information on age, gender and prior online course experience. Student identity remained anonymous.

4 Results and Discussion

Variety, extent and frequency of cheating practice

Group I – engineering students (n = 102)

mutual help over discuss groups during the test – 37, 3%
copying information from a mobile phone, flash-disk, diary, laptop) – 36, 3%
dishonest test acquisition (print-screen) from a class-fellow – 22, 5%
copying from a class-fellow's computer – 16, 7%

Never cheated – 42, 0%
Other forms of cheating were declared in less than 3% of answers.

Group II – engineering pedagogy students (n = 98)

giving or receiving advice from a class-fellow during the test – 100%
seminar work plagiarized from the Internet – 61, 2%
copying information from a mobile phone, flash-disk, diary, laptop – 25, 5%
dishonest test acquisition (print-screen) from a class-fellow – 24, 5%
copying from a class-fellow's computer – 9, 2%

Never cheated – 52%
Other forms of cheating were reported in less than 3% of answers.

In very few cases students admitted they had passed the exam for another person while misusing the person's password or while misusing remote desktop. Both cases were reported by 2 engineering students.

Comparing data related to the forms and frequency of cheating there were similarities and differences in both samples which could have been caused by characteristics of study programs. The prevalent forms of cheating as reported by engineering students were copying from a mobile phone, flashdisk, laptop, dishonest test acquisition from a class-fellow and mutual help over e-discuss groups during the test. Preference of electronic forms of cheating seems to be result of advanced ICT skills of engineering students and electronic testing dominance in engineering courses. Few students, on the other hand, were giving oral help to their class-fellows during the tests. 42% reported not to have cheated at all.

Engineering pedagogy students reported in all cases giving and receiving oral help from a class-fellow, plagiarism, copying information from a mobile phone, flashdisk, diary, laptop, and dishonest test acquisition from a class-fellow as the most frequent form of cheating. Test acquisition was probably influenced by carelessness of one teacher which enabled students to shoot the test and distribute it in other student cohorts. (Unfortunately, this teacher has not changed his behavior during exams after this accident as reported by students).

As mentioned, all students reported to have asked or given oral help to their class-fellows during the tests. This happened due to the fact most assessments had non-electronic form. 52% of the students reported not to have cheated (although all respondents from the engineering pedagogy cohort admitted to have given an oral help to their class-fellows!).

Motivation to cheat and subjective "justification" of dishonest behavior

To shed more light on internal justification of dishonest behavior the students were asked to consider 14 different factors and indicate the likelihood of each factor causing them to cheat. In this case a 5-point Likert scale was used, where 1 indicates "not at all" and 5 indicates "highly likely". The six most likely reasons which seemed most "justificatory" are shown in the following list:

Sample 1 – engineering students

I did not have time to prepare well
The task was too hard/had no sense
Too great a workload at technical university
I did not want to fail
The teacher did not control cheating
I used a crib I had prepared at home

Sample II – engineering pedagogy students

I had no time to prepare
I was afraid of failing
The task was too difficult
One of our teachers has used the same tests repeatedly
I helped my class-fellow to pass the test
My class-fellow helped me as he knew how busy I had been

Results from both groups of respondents showed that six highest rated factors which could have caused frequency of cheating behavior related to the themes of time pressure, fear of failure and subjective difficulty (quality) of the task. These "excuses" agreed with what had been found in our previous research [3] and in other studies [11], and suggested these were common areas of difficulty for students. Prevalent forms of cheating were practices related to assignment work and test situations. Time pressure and task difficulty were also the most "acceptable" forms of cheating in students' views.

Analyses of data from our questionnaires also confirmed two broad-based themes of internal and external factors that explain the pressure that may cause students to adopt poor learning behaviors.

Internal factors represent personal (individual, psychological) factors over which the student has (should have) control and tend to be course independent. Internal factors are represented for example by poor time management, lack of home preparation for tests and exams (laziness?), lack of learning skills and skills to find resources, unwillingness to follow recommended good practice, inability to seek appropriate help, and low intrinsic interest in course.

External factors are those factors imposed on the students and usually depend on the environment in which students work. Among external factors that “caused” cheating behavior were indicated clumsy situational management, poorly designed tasks and easy availability of solutions (tasks are readily available, copied from textbooks or lecture notes), difficult learning situations accompanied by equipment failure.

In the accounts of their work on assignments and class tasks students described various poor learning experiences that they attributed to external factors. In many of these cases the students gave indications that they had cheated or were tempted to cheat. This is in contrast to the learning problems caused by internal factors where there were no admissions of cheating. The theory of attribution confirms that students are more likely to admit to cheating when they can excuse their behavior by external factors. “It is not my fault, it is someone else’s fault”.

Teachers’ attitudes toward cheating as perceived by students
Last three items of our questionnaire were targeted at potential relation between teacher behavior and the students’ readiness to cheat. It is difficult to get reliable data on such relation as reported in our previous research when we conducted a pilot study on this topic with the university staff. In a qualitative analysis of teacher reaction none of them had admitted behavior which would have encouraged student cheating. That is why we decided to use the indirect method to get some insight into the teacher attitudes.

In both groups students reported 4 possible teacher behavior patterns: tough control of students during the test, moderate control over the student behavior, play acting of control and obvious ignoring of student intentions to cheat. Although all 4 options were reported, more than 2/3 of the students declared teachers were practicing tough control during tests. No significant differences appeared in both groups. More than 50% of respondents admitted their readiness to cheat in relation to the personality of teachers and the quality of their test management competences.

5 Conclusions

Evidence from our study suggests that university study of any discipline offers particular opportunities for students to engage in cheating behavior. On the other hand it is possible to assume that students might want to take responsibility for their learning. For a teacher it is important to help students to develop strategies to manage the internal factors that lead to poor learning tendencies. It is also important for educators to address external factors which are caused by characteristics of the learning environments. Such strategy can devise activities that academics can employ to minimize students’ propensity to cheat within their discipline. This is another approach to the one taken by many universities that focus on cheating detection and disciplinary measures – handling consequences rather than preventive methods. The opportunity to cheat is smaller when the teacher keeps an active position and requires that all notes, electronic devices, and other materials are put away and watches the students while working on tests. In other words teachers must be proactive in minimizing the three elements of the fraud triangle both in the traditional and in the online exam environment.

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Work in Progress: A Culturally Specific System to Improve Student Academic Integrity

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Abstract. Student honesty is a universal issue, however the reasons behind dishonest behaviour are complex and varied. This work in progress presents the development of a culturally focussed, online learning course designed to make students aware of issues surrounding academic integrity. This system has been designed to operate in a Muslim education environment, and attempts to take into account the specific needs, pressures and motivations of the students in this culture. A main, theme centres on the context of how personal academic integrity relates to being a good Muslim in an educational environment. This system is implemented on the university's learning management system and will be completed as part of a mandatory first year English course.

Keywords: Academic integrity · Honesty in education · Online learning modules · eLearning

1 Introduction

It is well documented that student cheating at the university level is on the rise [1, 2]. Whether it is a values argument or simply the ease with which cheating has become possible due to readily available access to purchased papers and information over the internet, curbing these violations is a high priority for universities [5, 7]. Software tools such as TurnItIn and exam control software such as Respondus seek to provide technological solutions to curb such activities. But these do not address the root of the problem. Whether the reasons for cheating stems from laziness, indifference, lack of understanding, or simply the stress that university work puts on students, instilling values of performing academic work honestly is of the utmost importance. Cheating and other forms of academic dishonesty serve to devalue degrees, teach poor life lessons and can have serious, sometimes even harmful consequences, especially for those pursuing careers in science and engineering.

Similar to most universities, Khalifa University of Science and Technology, an engineering institution located in Abu Dhabi, is seeking ways to curb instances of cheating and other activities related to academic dishonesty. There also exists a need to make students aware of the systems at the university that both: (1) aid students with handling stresses and pressures that might lead students into making poor choices to cheat, and (2) come into play after a student has committed a violation.

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A committee was formed to discuss the implementation of an online learning module based around issues related to academic integrity. This multi-disciplinary committee consisted of two student counselors, two instructional technologists and a librarian specializing in running workshops on issues related to plagiarism. The requirements for implementation as determined by the committee included:

1. Must be able to track who has and who has not successfully completed the module.
2. Must need minimal faculty involvement.
3. Must be able to generate a completion certificate.
4. Must contain culturally appropriate content.
5. Must be engaging and relevant to our learners.

Khalifa University is an English-language university located in Abu Dhabi, the capital of the United Arab Emirates. Our unique student base includes a majority population who speak English as a second-language (ESL). Additionally the majority of students are Muslim, with religion playing a very large role in their lives and in the country as a whole. In our research we came across many online solutions that addressed academic integrity, including out-of-the box and highly customizable solutions. We found most of the solutions consisted of text heavy content which is not considered the most effective teaching strategy for ESL learners [3, 6]. But more importantly, we found much of the content in these pieces to have a significantly Western emphasis. The images and videos of students did not visually represent the students on our campus, and all too often the learning scenarios used were aimed at a more Western lifestyle. One example included a question about best ways to deal with stress, with one possible answer being "go to the pub and have a drink." Definitely a fun and acceptable for a Western university student but not suitable for our student audience. Ultimately we found no suitable system suitable for our needs and therefore decided to create a custom course.

2 Creation

To fully inform, and appropriately motivate our design, we began by conducting interviews with students and faculty to address the following questions:

- What does academic integrity mean to you?
- Why do you think academic integrity is important?
- What are some ways you think students violate academic integrity?
- Do you personally know a student who was caught being academically dishonest? If yes, what happened to the student?
- The interviews were conducted on-camera with a few student volunteers, including the current student body president. Staff interviews were also conducted with the President of the university, the Associate Dean of the College of Engineering, senior members of the counseling team and a few teachers selected based on their involvement with the student body. Given that our campus has staff from all over the world, we aimed at canvassing a wide variety of opinions, including local UAE nationals, and expatriates from the GCC and "Western" nations.

- The student interviews we conducted revealed a consistent theme; students viewed academic integrity as important because honesty is essential to being a good Muslim and community member. This crucial observation led us to embed these values as the core theme in our bespoke system.

3 Design and Content

It was our determination to create a strongly student focused design that incorporated images and content which our student population would find relevant and engaging. To those ends, we wanted to have a face of the course in the form of avatars, for students to have ownership of the content, and for the essential subject matter not to be a dry regurgitation of the plagiarism rules and regulations (which had already been largely ineffective and hence motivated the creation of this system).

Avatars. In order to personalize the system and engage the students we chose to use two avatars (Fig. 1 left), to guide students through the content of the course. It was important to us that our avatars be physically representative of the students from this part of the world. Due to limited resources we had no ability to engage designers to create custom characters for us so we searched for pre-built solutions. Graphics sites such as iStockPhoto yielded no images of the traditional UAE dress for both men and women, and we found that images of people from any other Arab states were difficult to find. We eventually found a service called GoAnimate which gave us the ability to outfit two animated characters in the traditional dress of the UAE; the kandura for men and abaya for women.

Student Designed Graphics and Videos. The committee held a competition at the university which challenged students to create media (i.e., images, videos, posters, artwork, etc.) that illustrated the importance of honesty in education. We received several submissions including two, highly entertaining student videos acting out different cheating scenarios. Additionally, we approached other artistic students to create illustrations of students that represented some of the stresses we had identified as

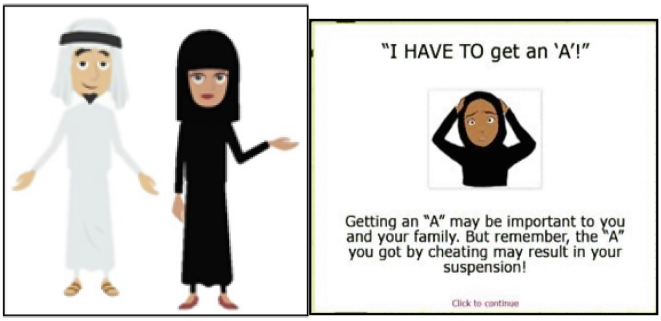

Fig. 1. **(a, left)** Ibri and Fatima, our student guides for the course **(b, right)** An example of a student designed illustration used in our academic stressors learning activity.

potentially leading to student cheating and violations of the honor code (Fig. 1 right). It was our strong desire to include as much student generated content as possible as a way of engaging the students and instilling ownership in the process.

Subject Matter. Academic integrity is a wide-spanning topic, and one most people instantly associate with plagiarism. However, while plagiarism is an important topic, we are also inherently interested in determining and remedying the underlying causes (and not just the resultant actions). Consequently, a significant focus of this system aims to help raise student awareness of these root motivators, present to them assistive resources, and also raise awareness of the university policies and procedures for dealing with academic violations. We endeavored to avoid including the minutiae of proper citing and paraphrasing that often is part of plagiarism curriculum.

The module, called iPledge, consists of seven units, six of which are formative, teaching content with the seventh being a final summative quiz. Each of the six teaching units consist of:

- content delivered via the aforementioned two avatars,
- custom videos of faculty and student interviews and/or student created content and/or quotes from Muslim leaders such as the late H.H Sheikh Zayed
- a learning activity to test the knowledge of the learner.

The topics of the six units are:

1. What is Academic Integrity?
2. Why Do Students Cheat?
3. Types of Academic Dishonesty
4. Why is Academic Integrity Important?
5. Exam Rules
6. Where To Go For Help

Learning Activities. At the end of each unit, a learning activity must be completed that is designed to test or reiterate the content just taught, and to provide interactivity to spark learner engagement with the module. Ultimately these activities are designed to be entertaining and informative, not difficult. We employed several different types of interaction in order to keep the learner engaged, including:

- Students will type the university honor code.
- A match game in which the learner tries to match two cards to identify the academic stress in the pictures.
- A text entry area which asks students to enter things they find stressful and difficult about university life. The answers will be stored for further analysis after the initial trial is completed.
- A multiple-page drop-down activity consisting of fill-in-the-blank statements taken directly from the university student handbook. This activity will require the students to have the handbook on hand in order to familiarize them with using it as a resource (Fig. 2 left).

Fig. 2. (left) Student use the student handbook to fill-in-the blanks on policies related to cheating, collusion, fabrication of research results, and sabotage **(right)**. This interactive exam room shows seven different violations of the university exam rules.

- An activity employing some principles of gamification, modeled after a choose-your-own-adventure game, will take learners through a scenario of a student who cheats and the outcome of those actions. This activity will introduce students to the university procedures that are engaged when a violation is suspected.
- An interactive, animated exam room will be presented to the learner for them to choose the students they see breaking the exam room rules (Fig. 2 right).
- A campus map will be presented detailing who and where students can get help and support if they need it.

4 Deployment

The anticipated deployment for the module is the Fall 2016 semester into all English I sections. The module, designed to be SCORM-compliant, will allow us to track which students have completed the module. In order to incentivize participation, points will be awarded that contribute towards the student's final grade. It is the aim that all students in the university will complete the module by the end of the 2016 semester.

5 Challenges

We have encountered several challenges in the development of this module. One issue is finding the right voices to use for the avatars. Given that the characters are representations of local residents, the appropriate accent is necessary. Conducting voice auditions in itself has been informative and has affected the content and script itself. We have learned the phrase 'Academic Integrity' does not translate well in Arabic so we are exploring alternatives. Additionally, determining how to teach ethical completion of group work as proved challenging. An important aspect of Islam is its culture of sharing, a principle which is embedded in our students throughout their lives. A significant challenge is how we can embrace this sharing ethic while differentiating plagiarism.

6 Future Work

It is critical to determine whether this system has any real impact on student behaviour as it relates to academic integrity. Metrics we are monitoring to gauge this include: reduction in instances of plagiarism and cheating, increase in the usage of student support services and before/after student assessment surveys. Our next steps will involve the creation of a pre-system engagement survey.

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International Comparison of Media Usage Among University Students

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Abstract. A survey on media usage was conducted at Western University, followed by similar surveys in Germany, Spain and Thailand. It seems that the usage of IT-devices is more popular in Thailand and Germany than in Canada. The use of social network related applications in academia seems to be more common in Thailand compared to Canada and Germany. The competitiveness of the Internet-based market of academic education might be more intensive in Canada because of the proximity of the U.S. market. An international comparison is, nevertheless, problematic, because the circumstances are really diverse and in constant change. Future plans involve conducting a comparative global media survey in the area of higher education.

Keywords: Media usage comparison · Media in education · Educational · e-Learning · Technology-enhance learning

1 Introduction

The integration of IT media and services in higher education has led to substantial changes in the ways in which both students and instructors study, learn, and teach (Johnson et al. 2014; Carapucu and Capretz 2012). Accordingly, surveys of students' and instructors' media usage habits have been conducted in Canada, Germany, Spain, and Thailand. These surveys purport to measure the extent to which media services are used in teaching and learning as well as to assess changes in media usage patterns. In addition, the surveys comprise part of an international research program in which 20 universities from 10 countries are currently participating.

The survey tool was first developed in 2009 and used at Karlsruhe Institute of Technology (KIT) in Germany (Grosch and Gidion 2011). During the course of 15 follow-up surveys that were administered on an international basis, the original survey underwent optimization, translation into several languages, and validation. The data for this survey was collected online using a well-established online survey tool called Unipark.

In 2013–2014, the survey was administered at Western University to undergraduate students and faculty members (Gidion et al. 2016; Gidion et al. 2014a; Gidion et al. 2014b; Gidion et al. 2013). The instructor survey, which resembles the student questionnaire, intends to compare the media usage of students and instructors by examining possible divergences in media culture that may create problems in the use of media for studying and teaching.

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There is no doubt, however, that the integration of IT media and services in higher education appears to have led to substantial changes in the ways in which students study and learn. Higher education institutions are cautious about investing in programs to provide students with mobile devices for learning due to the rapidly changing nature of technologies (Alrasheedi and Capretz 2013a). The acceptance of technology-enhanced education by students has increased in recent years, but not all services are equally accepted (Ali et al. 2014). It has become clear that simply using media and adopting e-learning does not necessarily make a difference in student learning (Alrasheedi and Capretz 2013b). Rather, pedagogy and the quality of the services are key factors for the effective use of technology (Ali et al. 2012).

2 Research Methodology

The surveys focused primarily on the media usage habits of students. Based on an assessment of the way in which media use relates to teaching and learning, the identification of trends provides an evidence base upon which more reliable predictions can be made about future trends of media usage in higher education.

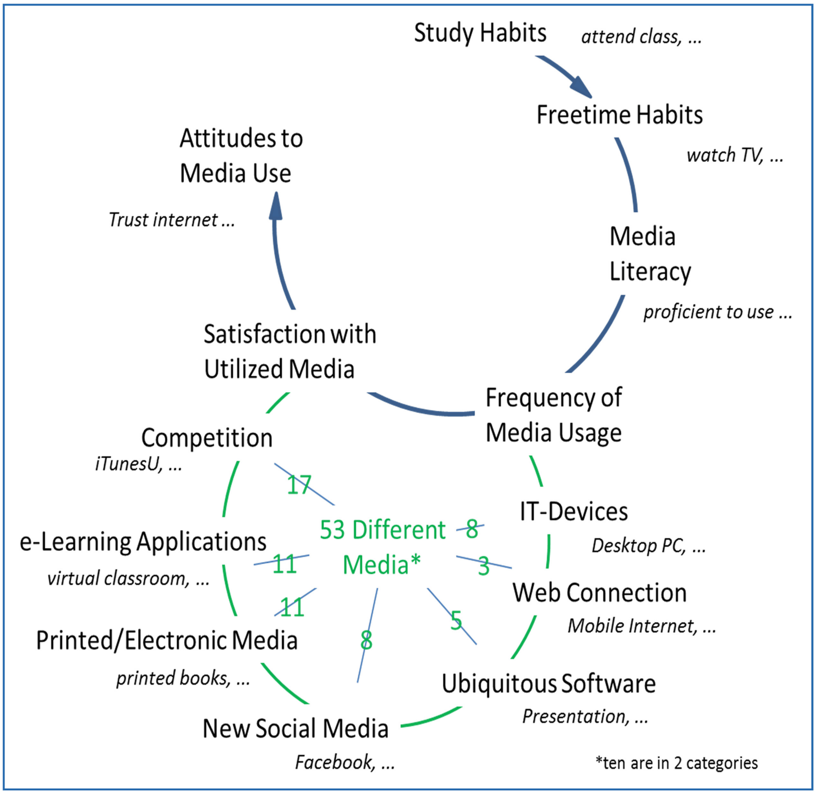

Fig. 1. Schematic display of the categories of the surveyed items

The surveys were anonymous and consisted of 150 items measuring frequency of media usage and user satisfaction with 53 media services, including:

- Media hardware such as Wi-Fi, notebooks, tablet computers, desktop computers, and smartphones.
- Information services, such as Google search, Google Books, library catalogues, printed books, e-books, printed journals, e-journals, Wikipedia, open educational resources, and bibliographic software.
- Communication services, such as internal and external e-mail, Twitter, and Facebook.
- e-Learning services and applications, such as learning platforms and wikis.

Additional variables were also evaluated such as some aspects of learning behavior, media usage in leisure time, educational biography, and socio-demographic factors, as displayed in Fig. 1.

3 Results and Discussions

The survey in North America followed the same concept as surveys in Europe and Asia. An international comparison is, nevertheless, problematic, because the circumstances are really diverse and in dynamic change. In addition to that, the trends could

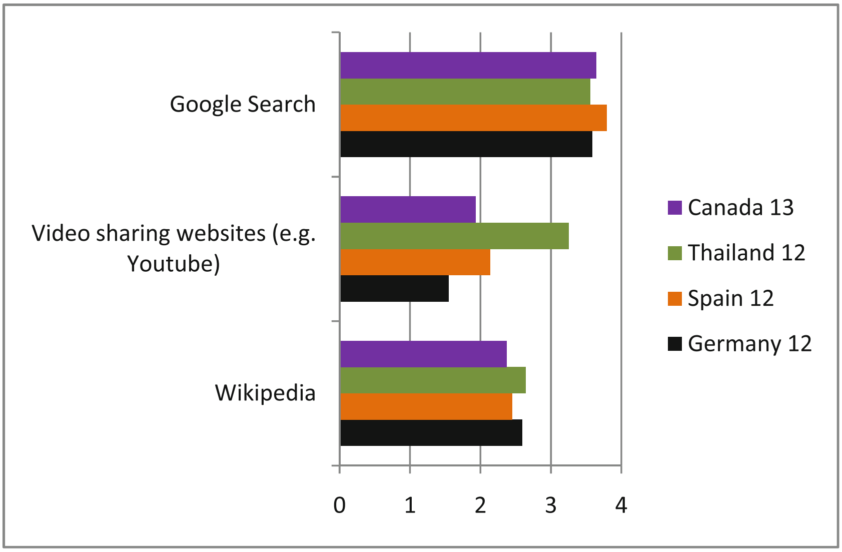

Fig. 2. Students from 4 selected universities: one each in Canada (valid n = 985), Germany (valid n = 1236), Spain (valid n = 981), and Thailand (valid n = 968), answer the question: How often do you use the following for learning/studying?), the question was rated on a five-point Likert scale with the following choices: “never” (0), “rarely” (1), “sometimes” (2), “often” (3), and “very often” (4) (or equivalent; the figure shows the means of all those who answered these questions.

just be interpreted if repeated surveys have been conducted. So it is risky to answer questions about international similarities and differences, but some of the results can be documented in four parts:

3.1 Selected items concerning the usage frequency of social network applications.
3.2 Selected items concerning the frequency of printed vs electronic media usage.
3.3 Selected items concerning the frequency of internal vs external media.
3.4 Selected items concerning the frequency of e-Learning applications usage.

3.1 Frequency of Usage of Social Networks Related Applications

The utilization of Google search seems to be prevalent in all cases, and Wikipedia has a certain relevance on a lower, but also remarkable level in the survey results from all 4 universities – slightly more in the German and the Thai case. The results concerning the usage of video sharing websites like YouTube show a higher value in Thailand, followed by Spain and Canada, the lowest value in the German case, as depicted in Fig. 2.

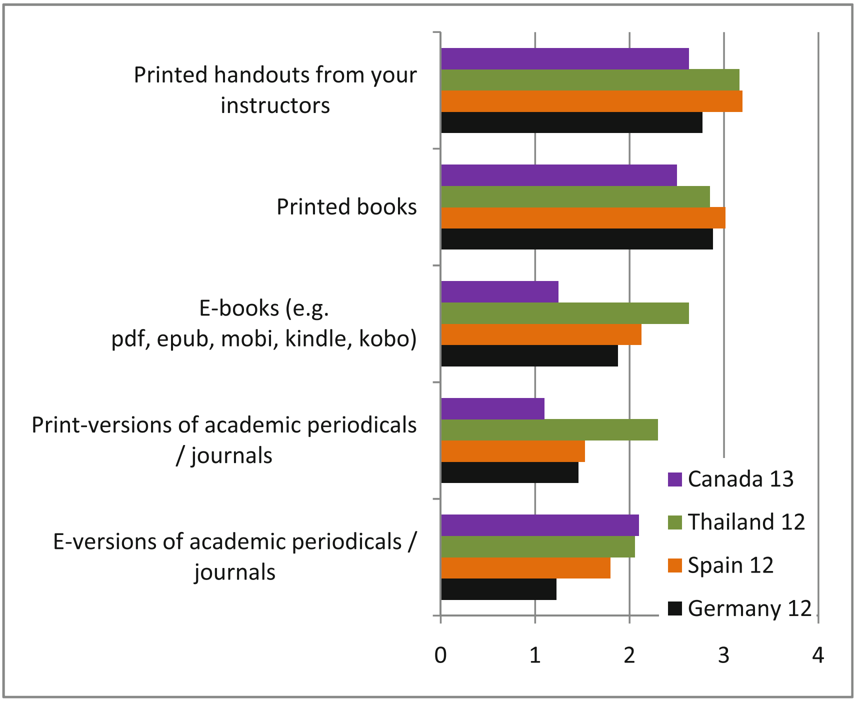

Fig. 3. Students from 4 selected universities: one each in Canada (valid n = 985), Germany (valid n = 1236), Spain (valid n = 981), and Thailand (valid n = 968), answer the question: How often do you use the following for learning/studying?), the question was rated on a five-point Likert scale with the following choices: "never" (0), "rarely" (1), "sometimes" (2), "often" (3), and "very often" (4) (or equivalent; the figure shows the means of all those who answered these questions

3.2 Frequency of Printed vs Electronic Media Usage

Looking at the results from the 4 universities, a few items from the group of printed vs electronic media usage might be interesting for the similarity or difference between the international locations. The Canadian case came to lower usage frequency values for “printed handouts from your instructor”, “printed books”, “e-books” and “print-versions of academic periodicals/journals”, but higher values for “e- versions of academic periodicals/journals”. Thai students seem to use e-books and print-versions of academic periodicals/journals more frequently than students in the other three cases. The German students show the lowest result of these four universities in the item “e- versions of academic periodicals/journals”. Figure 3 display more detailed results for this question.

3.3 Frequency of University-Internal vs External Media

Concerning the usage frequency of universities own vs external media services it might be interesting to look at three items that stand for the different sources. Online material (lecture notes) and/or scientific articles from your instructors are stated to be more frequently used than the other two items, “recorded lectures (audio, video)” – that might come from internal or external sources – and “online materials from other universities (e.g., iTunesU, Coursera, MIT Opencourseware)”, with a somewhat higher value in Canada and Spain compared to Thailand and Germany. Recorded lectures

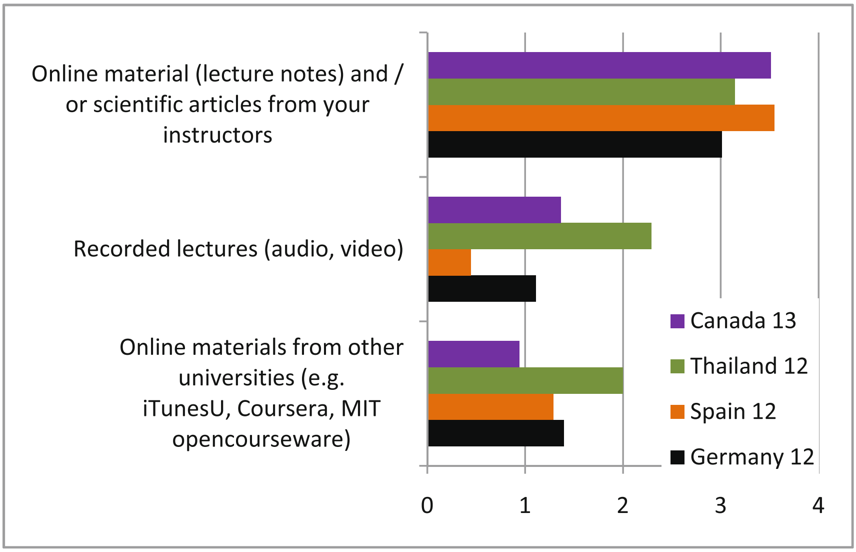

Fig. 4. Students from 4 selected universities: one each in Canada (valid n = 985), Germany (valid n = 1236), Spain (valid n = 981), and Thailand (valid n = 968), answer the question: How often do you use the following for learning/studying?), the question was rated on a five-point Likert scale with the following choices: “never” (0), “rarely” (1), “sometimes” (2), “often” (3), and “very often” (4) (or equivalent; the figure shows the means of all those who answered these questions

seem to be more common in Thailand, the same for online materials from other universities, which are (surprisingly) at the moment less often used in Canada than at the other three involved universities, as shown in Fig. 4.

3.4 Frequency of e-Learning Application Usage

Looking at the means of four involved universities, it can be stated that university websites are slightly more frequently used in the German university, followed by the Spanish and Thai and with a distance by the Canadian university, as presented in Fig. 5. The usage frequency of the Learning Management System is higher in the Canadian case, the Thai University shows the lowest frequency usage value in this item. There it seems to be more common – in comparison to these three other institutions – to utilize e-Learning applications as a part of a course and wikis with active participation as part of a course.

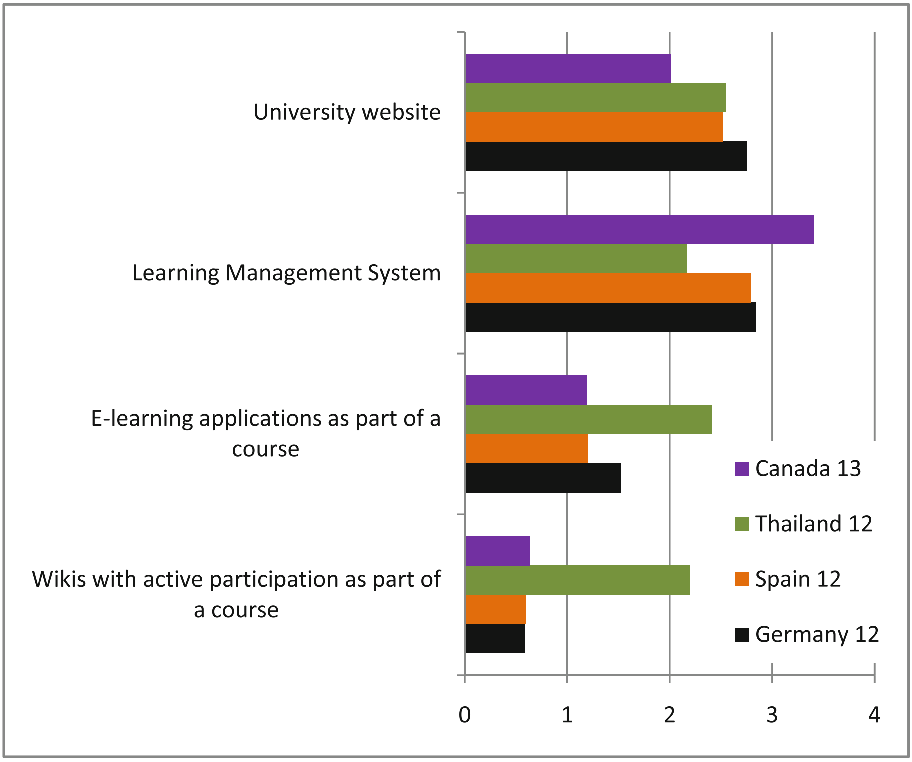

Fig. 5. Students from 4 selected universities: one each in Canada (valid n = 985), Germany (valid n = 1236), Spain (valid n = 981), and Thailand (valid n = 968), answer the question: How often do you use the following for learning/studying?), the question was rated on a five-point Likert scale with the following choices: “never” (0), “rarely” (1), “sometimes” (2), “often” (3), and “very often” (4) (or equivalent; the figure shows the means of all those who answered these questions.

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Lifelong Learning and Academic-Industry Partnerships

Collaboration Among Educational Institutes, Industries and Citizens in a Local Community for Realizing Enhanced Science Literacy Through Successful Science Events

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Abstract. Youngster's Science Festival in Chitose was started 10 years agok, and since then, this science event has been held once a year. Its original and main objective is laid in providing children in local community with opportunities for triggering their interests in various fields of natural science and technology through experiment demonstrations. In its early years, majority of demonstrators were active and retired teachers from elementary to ternary schools and educational institutes as well as university and high school students. Some people from industrial sectors also joined to serve as demonstrators explaining some technologies related to their corporate activities. The number of such participants from industry has been recently increasing. Moreover, scopes of the demonstrations have been expanded over the years so as to include certain fields in social sciences. For such fields, local residents who are voluntarily involved in lifelong educational activities have become main demonstrators who explain their achievements. Now, Youngster's Science Festival in Chitose has become a successful science event in the local community which has been served as appropriate opportunities, not only for providing children with triggering opportunities for getting familiar with STEM (science, technology, engineering and mathematics) fields, but also for allowing wider generations from parents to grandparent ages to enjoy lifelong educational activities. In order to enhance advantages obtainable through the event, establishment of collaborations among various sectors in the local community is very important.

Keywords: Science event · Outreach activities · Collaboration · Lifelong education · Science literacy

1 Introduction

Lack of interests of elementary and secondary school students in science and technology has been a serious problem to be overcome in Japan for recent years. Specifically, several statistical surveys typically show that students in elementary and secondary schools in Japan are likely become less interested in science and technology

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as they get older. For example, children in elementary schools are often very interested in various natural phenomena they can find and experience in their daily life, and thus, they get interested in studying sciences at schools. However, students in junior high schools and high schools are likely to lose their interests in science, especially in physics. It is often explained that learning mainly through textbooks via mathematical explanations without experiencing experiments are causing undesirable situations. Thus, allowing students to actually experience various science experiments is often believed to be effective for overcoming such situations.

In connection to the above views, empirical impressions imply, and at the same time another survey actually shows, that students of junior high schools and high schools who have had more experiences with natural phenomena at their younger ages are likely to keep their interests and remain positive towards learning science subjects even in higher grades. Therefore, in addition to providing active learning experiences in classrooms, allowing children and students to have effective out-of-classroom experiences, especially at their younger ages, seems also important for enhancing their interests in learning science and technology.

For realizing the above-mentioned purpose, out-of-classroom science events will be advantageous. Moreover, in order to further enhance possible advantages through those out-of-classroom science events, it is essential to establish collaborations among various sectors in the local community so that children can be exposed to wide ranges of experiences in various fields of science and technology.

One of such out-of-classroom science activities held in Japan is Youngster's Science Festivals, which are held at various places throughout Japan every year. This is a science event at which children and other participants in wide ranges of generations can enjoy various experiences of experiment and observation demonstrations mainly in the fields of natural sciences, provided usually by active and/or retired school teachers.

The author has been responsible for organizing one of such events (i.e., Youngster's Science Festival in Chitose) over 10 years in a local town named Chitose, as the head of its steering committee. Different from the similar events at other places, the author and other committee members in Chitose are trying to establish collaborations with various sectors in a local community, such as educational institutes (including active teachers and their students), several companies from local industries, as well as citizen volunteers (including retired school teachers) and their groups. This aims to provide children and other participants with much wider exposure experiences to various fields of science and technology.

The event has also become advantageous for certain groups of local citizens in senior generations for allowing them to have lifelong education opportunities. More specifically, they can have chances to make presentations about established achievements in their lifelong educational activities, and also to learn new things through interactions with other demonstrators and/or audiences with various backgrounds and in different generations.

Thus, Youngster's Science Festival in Chitose now has unique characteristics in which the event can now serve as a forum, not only for children and young students but also for wider generations from children to senior and/or retired generations, to obtain appropriate educational opportunities, as explained below.

2 Youngster's Science Festivals in Japan

Youngster's Science Festivals were first held in 1992. There existed certain serious backgrounds.

Specifically, in 1980's, significant amount of Japanese younger generations (especially junior-high school and high school students) were found to have little interests in science and technology. That urged educational sectors in Japan to search for any solutions for letting the Japanese younger generations be more interested in various fields of science and technology. They thought that one of possible reasons why the Japanese younger generations were losing their interests in science and technology would come from the classroom situation in which they were not provided with sufficient opportunities of actual exposure experiences for science and technology. Although learning and obtaining sufficient knowledges was of course important, actual exposures to the various fields of science and technology (i.e., performing actual science experiments and manufacturing experiences) could be effective opportunities for the younger generations to be voluntarily triggered to become more interested in learning science and technology. However, in junior high schools and high schools, performing experiments for the students in classes often became difficult for several reasons. Thus, some new activities were expected to be organized.

Based on such backgrounds, in 1992, Japan Science Foundation started Youngster's Science Festival at Tokyo, Nagoya and Osaka, as an experience-oriented out-of-classroom science event. As its original aims and scopes of this science event, children and junior-high school or high school students were expected to come and have real experiences through various kinds of activities including experiments, observation and demonstration as well as small scale manufacturing and/or craft work experiences in various fields of science and technology.

Since then, the number of Youngster's Science Festivals to be annually held has increased and the event sites have been spread over the entire Japan. In most cases, the steering committee is organized by active and/or retired teachers of elementary to ternary schools, staffs of local educational institutes, researchers and engineers in industries as well as voluntarily-interested local citizens in a local community. They themselves prepare for various science experiments as well as craftwork experiences, or ask others to do so. Children and their parents or grandparents as well as people in other generations can come to the event site and enjoy experiments and actual experiences in various fields of science and technology.

Experiments and demonstrations are usually related to various fields of natural science (such as physics, chemistry, and biology) and as well as manufacturing and engineering fields.

Although the word "Youngster's" has been still used, the majority of audiences are likely to be elementary school and kindergarten children or infants with their parents and grandparents in recent years. Junior high school and high school students are less likely to come to the event sites as audiences. Instead, many of them are likely to actively participate in the events as demonstrators.

Thus, over the history of about 25 years since its beginning, Youngster's Science Festivals have become popular experience-oriented sciences events in Japan.

3 Youngster's Science Festival in Chitose

3.1 The History of the Science Festival in Chitose

The city of Chitose with population of about 95,000 is located in Hokkaido, the norther part of Japan. The Youngster's Science Festival in Chitose was started in the year of 2006. At that time, the Science Festivals had been already held annually in some of the nearby larger cities including Sapporo. However, for the city of Chitose, this was a new type of science-related educational activities.

Since then, the Science Festival has been annually held in Chitose on one Sunday in November, usually with 30 to 40 demonstration themes, as shown in Fig. 1, with about 100 to 150 staff people.

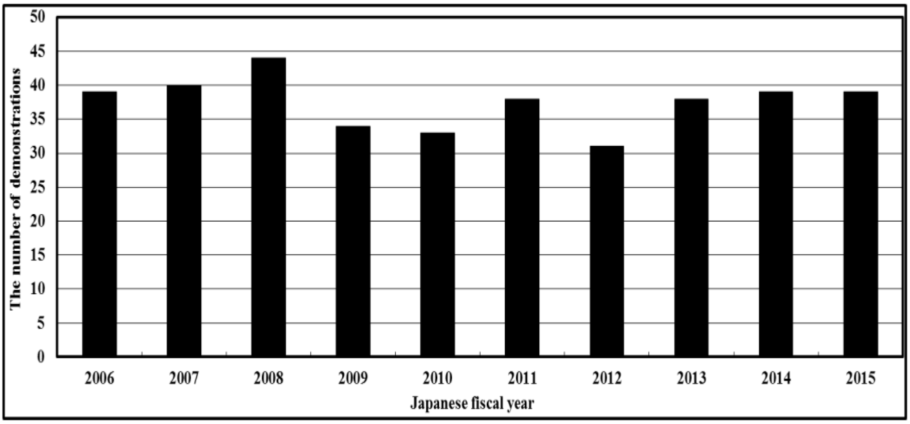

Fig. 1. The number of demonstrations for each year.

Figure 2 shows the approximate number of audiences for each year. The number of audiences varies each year, depending on several factors such as the weather conditions of the particular day. Although the exactly counted number is not available, Fig. 2 reveals that about 2,000 to 2,500 people in wide generations from children to retired seniors come to enjoy the demonstrations each year.

The author has been involved in the event from its beginning as the head of its steering committee.

More specifically, in the year of 2005, the author was contacted by some local people who were active in science voluntary activities in the local community. Those local people were interested in organizing some experience-oriented out-of-class science activities in the city of Chitose for the purpose of allowing children in the local community to have actual experiences of science experiments and demonstrations in various fields so that they would get more interests in science and technology. Thus, collaboration among us was established to organize the steering committee for Youngster's Science Festival in Chitose. Then, the Festival was started in 2006.

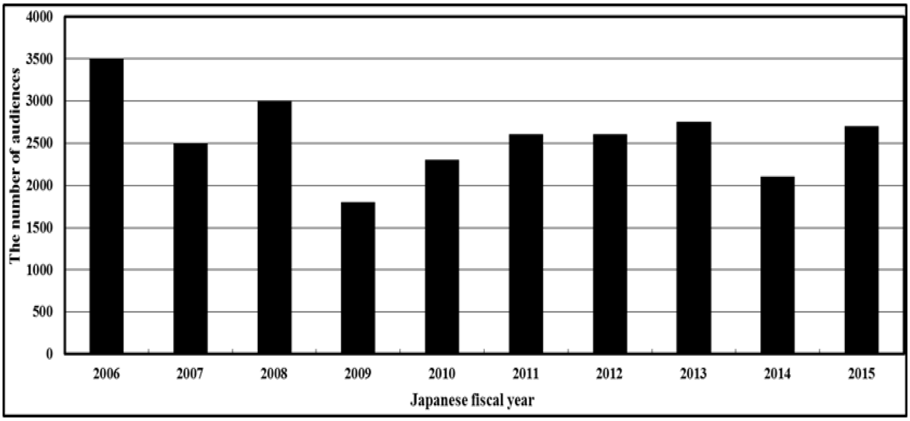

Fig. 2. The approximate number of audiences for each year.

For the first 6 years (from 2006 to 2011), financial supports from Japanese Science Foundation were used to cover expenses. Since the 7th year (2012), financial supports have been provided from the local city government. Specifically, the event is now incorporated in the lifelong social education plan of the local city government, and can be organized by means of the local government budget.

3.2 Unique Aspects of the Science Festival in Chitose

At most of the demonstration themes, participants can usually have actual experiment experiences and/or watch experiments to be performed by demonstrators (See Fig. 3).

Similarly in the other Science Festivals at other places, the demonstration themes at the Youngster's Science Festival in Chitose include the subjects in various fields. However, different from the other places, the demonstrations in Chitose Festival are likely to include, not only from those in the field of natural sciences such as physics, chemistry or biology, but also those from the fields of social sciences related to, for

Fig. 3. Some photos of the event site.

example, history and/or cultures in the local community. For the demonstrations in social sciences, some panels are often displayed and explanations were provided to the audiences by the demonstrators.

Thus, the Science Festival in Chitose has its own style in which children and other participants can enjoy various fields of “sciences (both natural and social)” so that they can find some topics in which they can get really interested.

Among various demonstrations, active teachers and retired teachers from elementary, secondary to ternary educational institutes often offer experiment experiences usually related to several subjects found in textbooks. Students from high schools and universities also offer experiment demonstrations relating to their out-of-curricula activities, as can be seen in Figs. 4 and 5. It is clear that for high school and university students, experiences as demonstrators, in other words, experiences of explaining their demonstrations to others, can serve as useful opportunities for obtaining new knowledges and/or renewing their understandings relating to their demonstrations. For example, the university students’ project team “Rika-Kobo” [1–3] organized by students of the author’s university takes part in this event every year and the student members can obtain ideal experiences for their career development.

Fig. 4. A science show (left) and explanations of demonstration experiments (right), provided by university students.

Fig. 5. Explanations of demonstration experiments provided by high school students.

Through such various demonstrations and experiment experiences, children and other participants visiting the event can have opportunities of knowing and learning fundamental knowledges in textbook levels. In addition, some topics of advanced levels are also provided through outreach activities of higher educational institutes.

In order to make the event more attractive and advantageous, the steering committee always tries to ask various sectors in the local community to participate in the event as demonstrator. As a result, people from different backgrounds actually provide various demonstrations every year.

For example, several manufacturing companies from local industries provide demonstrations and experiment opportunities relating to their products as well as manufacturing processes. As another example, an airline company offers an aviation class in which several technical subjects in aviation, airplane technologies, and some techniques utilized at airports will be explained (See Fig. 6).

Fig. 6. An aviation class performed by employees of an airline company.

Through those demonstrations offered by industrial sectors, children and other audiences can have opportunities of knowing how fundamental findings and knowledges to be learned in classrooms will be actually applied to and utilized in actual industrial scenes.

In addition, some citizen groups in the local community, who are active in lifelong educational activities and cultural activities, tend to take part in the Science Festival as demonstrators and show their achievements, as shown in Fig. 7. Their participations are especially desirable in order to provide some themes in the fields of social sciences, often directly related to the cultural and/or historical backgrounds of the local community, so that the scope of the Science Festival can be expanded. Audiences can learn a lot through their demonstrations, and especially parents to senior (grandparents) generations are likely to get interested in those demonstrations and explanations.

Thus, participations as demonstrators from industrial sectors and local active groups, in addition to those from educational institutes in various levels, are significantly important to widen the scope of demonstrations in the Science Festival in

Fig. 7. Displays prepared by a citizen group based on achievements of their lifelong educational activities.

Chitose, which really makes the Science Festival in Chitose more attractive and popular over the similar other activities in other places.

For the purpose of showing that various topics are provided, some of the demonstration topics performed in the Youngster's Science Festival in Chitose 2015 are listed below:

- LED lights
- Slime
- Mysterious colors in soap film
- Pascal's principle
- Up-and-down items in water
- LED optical communication
- Functions of electronic circuits
- Functions of magnet piece
- Agricultural machines
- Radioactivity
- Primary colors of light and colors
- Fruit battery cells
- Acid and alkali solutions
- Polarization of light
- Robot arm and flight simulators
- Nature of Lake Shikotsu
- Volcanic activities of Mt. Tarumae in the local area
- Chitose in Ice Age
- Aviation class (works at airport for safe and on-schedule flight)

As can be seen in the above listing, the demonstration topics are widely ranged from natural sciences to social sciences. Some topics are directly related to subject matters to be taught at classrooms, but others are more closed to actual application.

4 Obtainable Advantages

4.1 Responses from the Audiences

It is almost impossible to numerically access educational effects through this event. However, the fact in which over 2,000 participants come to this event every year will indicate that this collaborative science event becomes well-known in the local community and many families with children can enjoy the annual event.

The steering committee surveyed about 100 persons among the audiences at the site of the 2015 Science Festival in order to see how the audiences think of this Science Festival. A graph in Fig. 8 shows personal data of the respondents.

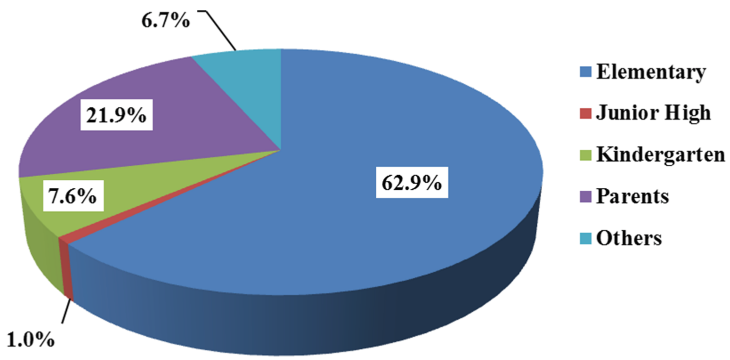

Fig. 8. Personal data of about 100 respondents at the Science Festival in the year of 2016.

The graph indicates that about two-thirds of the respondents were elementary school students. In addition, about 8% was kindergarten-age children. Although this may not be perfect reflection of personal data of the overall audiences, the majority of them were children at their younger ages.

When the respondents were asked their opinions about the Science Festival, most of the elementary school students told that they had nice time at the site and enjoyed various science experiments and demonstrations. In addition, some of them further told that although they were not good at science at classrooms, they had enjoyable experiences here and became interested in learning science. Thus, although quantitative evidences cannot be obtained, certain stimulation effects for children are believed to be obtained so that they can have effective out-of-classroom experiences effective for enhancing their interests in the fields of natural and social sciences as well as technologies.

Similar positive responses were also obtained from their parents and other senior generations. For example, one retired person told that he found there were still many new things to know from several kinds of experiments and demonstrations. Thus, this science event is advantageous even for various generations other than children.

4.2 Advantageous Effect Obtainable from Collaborations

As mentioned in the above, the Science Festival in Chitose is organized based on collaborations among many sectors. Some advantageous effects are obtainable through interactions between demonstrators and audiences as well as among demonstrators based on such collaboration.

(a) Participation from industrial sectors:

Since industrial sectors are also involved in the science event in addition to school teaches, children and other participants can have opportunities of knowing and learning knowledges in various levels from fundamentals or textbook levels up to advanced and the state of arts levels. Moreover, manufacturing companies are likely to introduce some manufacturing techniques actually utilized in their factories, which are not usually taught in classrooms. Thus, for student demonstrators, this can be good chances for learning and expanding their knowledges. However, parents and senior generations, rather than children and students, seem to be more attracted by such demonstrations from industrial sectors.

Participation from industry has another benefit in which local residents can have appropriate opportunities to know products and/or activities of the local industry. Specifically, when companies are not related to consumer products, local residents have little chances to become familiar to them, even when those companies are famous in the relevant industrial sectors. Demonstration from industry can compensate for such gaps.

(b) Lifelong education:

The event is also an effective chance in terms of lifelong education in the local community. Specifically, local citizens who served as demonstrators in the event seemed stimulated and encouraged for pursuing further studies through presentations and explanations about achievements. In addition, some certain communication opportunities are offered between demonstrators from the citizen groups and participants, especially in senior generations, over the demonstrated achievement results. Motivations for lifelong educational activities among local people can be spread through such conversations.

(c) Communications among demonstrators and audiences from various backgrounds:

Since demonstrators have various backgrounds, communications among them can become fruitful.

For example, university and high school students who take part in as demonstrators can have chances of making conversations with demonstrators from industrial sectors. Through such conversations as well as experiences of demonstrations/presentations from industrial sectors, they can know how the knowledges they are learning now at classrooms are applicable to actual manufacturing scenes. Such experiences can be effective stimulations for them to be triggered for studying further various subjects in science and technology.

(d) Improvement of science literacy

The final goal to be achieved through such collaborative activities is to improve and enhance science literacy in the whole local community. In such an atmosphere, children will have more chances to expose themselves to various experiences relating to science and technology, which can be believed to be effective for stimulating their interests in learning subject in various fields of natural science and social science as well as technologies.

5 Summary

The Youngster's Science Festival in Chitose has offered effective opportunities for children and other participants in wide ranges of generations to enhance their interests in various fields of natural and social sciences through collaboration among various sectors in the local community. The event has also provided local citizens with lifelong education opportunities. In order to enhance advantages obtainable through the event, establishment of collaborations among various sectors in the local community is very important.

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Public Investment on Education in Sardinia - The "Tutti a Iscol@" Project

Introducing Innovative Technology in Didactics

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Abstract. This paper presents the first step of the Autonomous Region of Sardinia new strategy to reduce early school leaving. The project will develop along a three-year period and school drop-out will be dealt with from various angles. The objectives are to improve students basic skills, to enlarge school offer by introducing Didactic Laboratories by means of the organization of extracurricular activities based on innovative technologies and to offer psychological support to students (lines A, B and C). In this paper we shall concentrate on Line B. The seven laboratories developed for Line B were conceived to take advantage of student's interest for technology and to increase their motivation to stay at school and reduce school disaffection, building at the same time a bridge between participating schools and the Sardinian economic actors.

Keywords: School dropout prevention · Extracurricular activities · Scientific and technological innovation · Technology enhanced learning activities

1 Introduction

One of the five European Union objectives to be reached by 2020, deals with education and specifically with keeping school drop-outs rate below 10% [1]. Based on their different national circumstances, each Member State is adopting its own targets, its own strategy. Italy's target is to keep drop-outs below 16% [2]. The Sardinian Autonomous Region (RAS) is one of the Italian Regions with the highest rate of drop-outs: 25,8% compared with an average of 17,6% in Italy [3]. In 2015, the RAS decided to invest in a project named "Tutti a Iscol@" (meaning "everyone at school") [4] to reduce early school-leaving and improve students skills and competencies, operating along three lines of action: line A: improvement of basic skills (€5 million); line B: inclusive schools (€4,5 million) in which the attention will be focused on the didactic innovation, and on the interaction between schools and the economic actors of the Region, called to provide their expertise by developing the laboratories-scenarios to be delivered to schools; and line C: psychological sustain (€5,5 million) for school students aged between 6 and 19 years old. This paper will describe specifically line B, named Innovative Didactic Laboratories (IDL).

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The duration of the project is 3 years and the budget allocated to academic year 2015–16 is €15 million. The Educational Technology team of CRS4 (Center for Advanced studies, Research and Development in Sardinia) was contacted by the Regional Authorities to identify the framework based on Technology Enhanced Learning (TEL) activities in which the lab-scenarios are to be developed. The public invitations to tender are issued under aegis of the Regional Agency Sardegna Ricerche (SR).

2 Main Objectives

The main objectives of the IDL project are: to increase students' motivation to stay at school and reduce school disaffection; to favour new teaching practices that integrate technology in both teaching and learning processes and enrich the school offer; to encourage students social inclusion both at school and within society; to build a bridge between participating schools and the economic actors of the Sardinian territory that have both technical knowledge and educational skills. In the timescale, our first objective is to reach and cover the greatest amount of schools around the whole Regional territory.

The activities launched in IDL are based on young people's interest for technology. They will be invited to experiment (in a playful way) situations in which they can investigate their problem solving abilities, increase their potential and self-confidence and develop key competences useful both at school and in real life. For example, through gaming and collaborative learning they will not only improve their technical skills but also their self-knowledge, and interpersonal communication skills. At the end of the experiment we expect students to have matured critical thinking with respect to innovative technology, and to have improved their relationship with the concept of staying at school.

3 Method

The challenges to be faced were many and time was a critical factor as the Regional Authorities wanted the project to be launched in Academic year 2015–16. We had to respect a very tight schedule and to put together a project that needed to be attractive to schools and students on one hand but also to the important third party: the economic actors (SMEs, Cultural Associations, University Departments, and so on). We also had to organize an information campaign, crucial to the success of the project.

The framework is composed of 7 technological areas, identified by the Educational Technology team of CRS4 as able to offer suitable innovative environments for schools, and offer a good potential to learn through gaming:

- **Augmented Reality (AR)** – for its positive impact on learning spatial structures, contextual elements and language association, long term memory retention, improved collaboration and motivation [5, 6].

- **Internet of Things (IoT)** – for the involvement in experiential learning, i.e. the process through which a learner constructs knowledge, skills, and value from direct experience [7]. The experiential hands-on approach can help students to become smart users, aware of the issues around using critically a new technology [8].
- **QR-NFC technologies** – for mobile/outdoors learning which is student-centered, active and collaborative; possibly situated and embodied; and potentially aligned with inquiry-based, problem-based, project-based and/or task-based [9].
- **Treasure hunt augmented** – for its capacity to improve spatial skills and to extend learning activities beyond the boundaries of the classroom. This area uses smart/mobile technology and outdoor AR. Such technologies facilitate seamless learning across learning contexts adapted to different kinds of spaces [10].
- **Knowledge Management (KM) and culture** – for the opportunity to discover the richness and variety of one's cultural surroundings, give visibility to artistic peculiarity, and reveal new enriched meanings otherwise hidden, learn how to share data and knowledge and put it to use, allowing new connections with actors from different cultural fields [11]. Capturing, creating, sharing and diffusing Knowledge has been the essential elements of KM defined as "the process of applying a systematic approach to the capture, structure, management, and dissemination of knowledge throughout an organization in order to work faster, reuse best practices, and reduce costly rework from project to project" [12].
- **Coding** – for problem solving and testing one's ability to analyze a problem, select an appropriate language/tool to solve it. The ultimate goal for the learner is the development of critical-thinking abilities, not to passively absorb and regurgitate information, but rather to actively engage with the content, work through it with others in a positive relationship that takes into account each personal experience, and effectively solve problems with the corresponding knowledge gained [13].
- **3D Food printing (food as pieces of games)** – for the learning by doing approach. Conceptual knowledge can benefit from 3D printing technology's capability to make malleable objects, shortening the time taken to devise a particular solution and then to evaluate the outcome. With 3D technology, one can learn faster through practice and be more productive through experience [14].

4 Pedagogical Aspects

Each identified technology used in the interactive laboratories was chosen not only for its technical characteristics, but also and mainly for its pedagogical potential. Areas in which improvement is expected:

- **Cognitive area**: to foster the cognitive cultural intelligence (knowledge of norms, conventions etc.), acquired not only from education but from their own personal experience; to develop the ability to receive and elaborate information; etc.
- **Metacognitive area**: to improve their mental ability to reflect on their own thoughts and behaviors, to observe with critical mind; to understand their environment and use their imagination and creativity, their ability to find original solutions to a specific problem etc.

- **Behavioral area**: to increase the ability to interact with peers and adults in an appropriate way; to improve their ability to present an argument and accept others points of view; to increase the capacity to use appropriate verbal and non-verbal actions to communicate with others, to be able to work in a team, etc.

Becoming main actors of their discovery paths, and becoming gradually aware of their new or increased abilities will have a positive result on self-confidence, on the desire to focus their energy towards learning - in short, on their motivation.

5 Procedures Followed and First Results

The information campaign was launched to inform schools, teachers and potential economic actors of the forthcoming call to be published on the institutional web sites of the RAS, SR and CRS4, and to invite them to participate. The seven technological areas of the interactive laboratories as well as the procedures to be followed to participate were illustrated during public meetings held in the major Sardinian towns see (Fig. 1). We estimate that at least 300 operators (school heads, teachers, economic operators) attended. Other means used were the media (local papers, local radio broadcasts, a festival of culture, and CRS4 social networks). All relevant information could be found on the platform developed by CRS4 for the project: http://iscola-lineab.crs4.it.

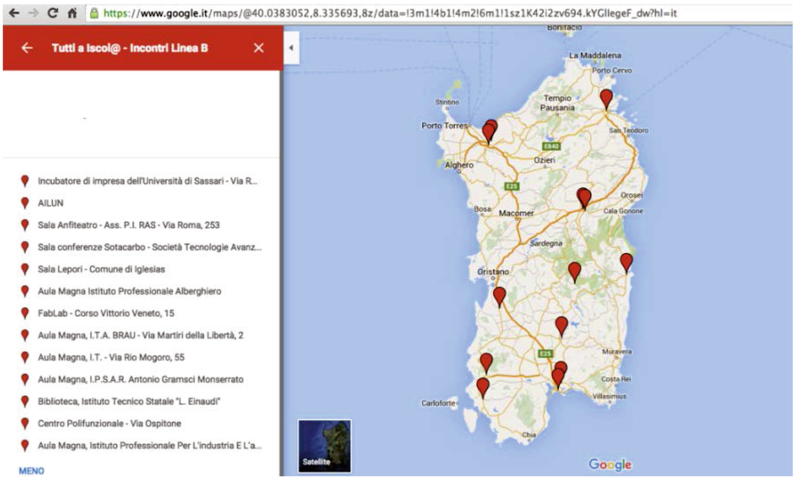

Fig. 1. Places where CRS4 and SR presented line B of the "Tutti a Iscol@" project.

Economic actors can present up to two types of laboratories. With duplication, this will turn into a maximum of 4 laboratories per economic actor. The proposals are examined by a commission made of educational technologists and a legal advisor which evaluates the originality of the activities, the pedagogical relevance and their technical qualities. All the technological areas identified are covered by at least 4 proposals from the economic actors.

The successful proposals are included in a computerized catalogue and loaded on the above mentioned platform. Ninety proposals (original ideas) from 66 different actors successfully passed the selection board. With duplication of most of them, we reached a total of 173 laboratories and all levels of education were covered (Fig. 2).

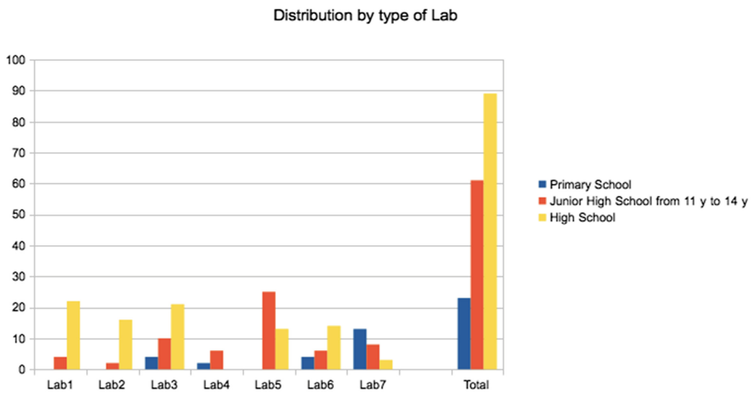

Fig. 2. Distribution by type of laboratory and by level of schools.

The distribution of the laboratories over the Sardinian territory is fairly homogeneous, and there are at least 30 potential labs available in each Province. But the distribution is not consistent with the distribution of the school population in the Provinces.

According to the National Institute of Statistics (ISTAT) 2015 data, Cagliari Province has 46,28% of the Sardinian school population, all levels included, Sassari province 30,60%, Nuoro province 13,84% and Oristano Province 9,28%. Although Nuoro and Oristano are the two poorest provinces of Sardinia, they have the lowest percentage of early school leaving students.

Most laboratories were conceived for high school level. This is an expected result, since the regional tender focuses on the problem of early school leaving.

Schools willing to participate registered on the official site of the Sardinian Region by a certain date. After being made public, the catalogue is accessible to the registered schools through Single Sign On and schools can draw up an ordered list of their preferred laboratories. The "Istituti comprensivi", which are schools which include all levels of education, may draw up a list for each level.

CRS4 platform, took into consideration both the priority list issued by the Region's Department of Education, based on both dropout rates and Pisa-tests in Maths and Italian language and literature and the preferences expressed by the schools. Through an algorithm it automatically made the match, giving a higher priority to schools with higher ranking (Fig. 3).

Schools were notified of the result of the matching procedure and the activities started between mid-March 2016 and early April 2016. Due to time constraints (the commitment for laboratory activities was 48 h for primary schools and 72 h for junior

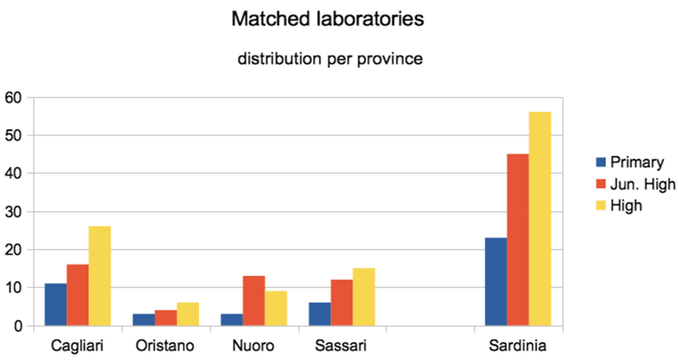

Fig. 3. Distribution of **matched** laboratories per Province

high and high schools, to be carried out in 12 weeks), and because the last term at school, students are full of activities such as tests, work linked training activities and so on, as many as 26,61% of the schools that initially were ready to participate renounced to join the project. Therefore, out of the 124 assigned laboratories only 91 actually came to life (Fig. 4).

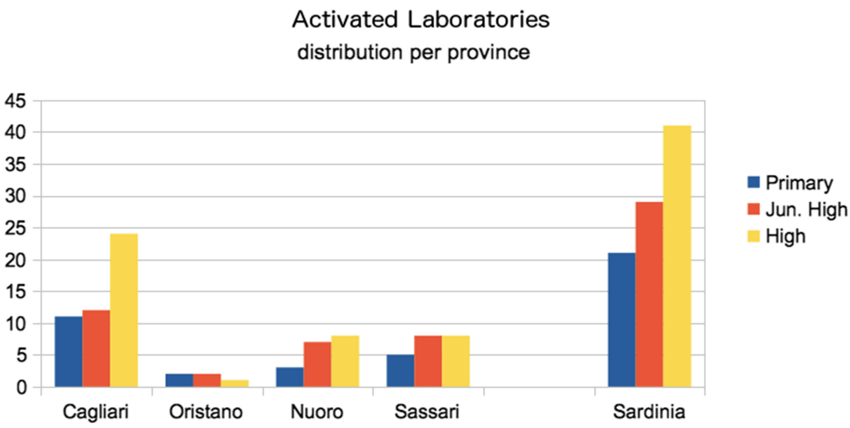

Fig. 4. Distribution of **activated** labs per Province.

6 Monitoring

Now, the project has entered the early stage of the monitoring phase which is foreseen to unfold in two ways.

On one hand, for each laboratory, all involved students, as well as one external tutor and one accompanying school teacher will be given an online self-administered questionnaire to be filled at the end of the project. On the other hand, a sample of 22 schools (Fig. 5), corresponding to 24.17% of active laboratories, was selected to be

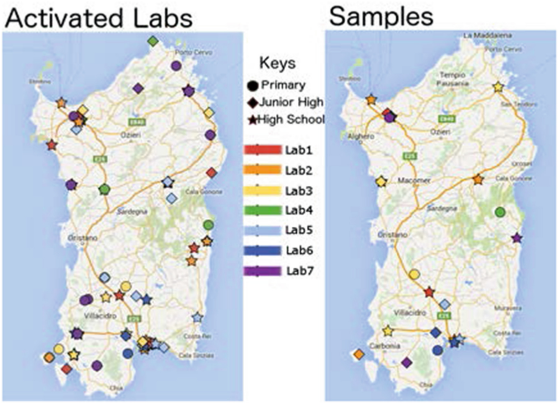

Fig. 5. Left: distribution of activated labs. Right: labs selected for the face-to-face monitoring.

interviewed by CRS4 staff (halfway through the activities and at the end of the academic year). The selection was done based on their dropout rate, the technology used in laboratory activities and the geographical position. For this phase of the monitoring process CRS4 researchers will want to meet with one of the school tutors involved in the extracurricular activities, one of the external tutors and 3 students chosen by the school because considered representative of the group.

Monitoring activities provide useful feedback on project management, enable to highlight eventual problems and make it possible to evaluate its efficiency. It will also give information to assess the impact of innovation on students' mental representation, based on the kind of laboratory he has been working in. Since the project is foreseen to unfold over a period of 3 years, it is important for us to monitor the educational changes occurring within the students (if any), and have their feedback on the organization of activities, on the topics and innovative technology dealt with inside the laboratories, the competence of the economic actors. This will enable us to make the necessary changes to improve the following editions of the project.

7 Conclusions and Future Work

The experiment started mid-March 2016. It is our feeling that the IDL project meets the needs of the Sardinian schools since their participation was meaningful: 142 schools out of 282 of all educational levels registered on the Regional platform to express their intention to participate and were admitted to the program. Taking into consideration the participation of schools, the proposals of the 66 participating economic actors (90 original ideas resulting in potentially 173 laboratories), and the fact that all Provinces were roughly equally covered, we can consider that the first timescale objective was reached. The next steps will be to follow-up the activity progresses, monitor the experiment, and based on the results plan the activities of future editions.

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Structural Development of Substance in Engineering Education: Method of Cornerstones

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Abstract. During the current millennium, engineering education has confronted an emerging problem with learning. Driving forces have mainly been economical, since financial pressure and effort for increasing efficiency have given rise to growing amount of accessed and graduated students. Consequently, in the lack of time and financial resources, universities have had a tendency to decrease the emphasis on thorough and time-consuming learning of fundamentals. As a result, so called immediate skills have gained excessive role in comparison with long-term skills in engineering education. According to a generally accepted view, students learn to carry out engineering tasks quite well, but they do not necessarily learn to think. Recently, a study carried out at MIT ended up to call for "coherent and interconnected curriculum structure" to achieve excellence in engineering education. We suggest that by utilizing the hierarchical structure of natural sciences in engineering education, such a coherent and interconnected structure can be created. In this paper, we show how the method of cornerstones is implemented to clarify engineering substance and to promote higher learning. By making cornerstone-based structure visible to students, we aim to clarify and harmonize the substance and to promote both immediate and long-term engineering skills.

Keywords: Engineering education · Higher learning · Method of cornerstones

1 Introduction

During the economic pressure of current millennium, a global worry about the lack of higher learning in higher engineering education has arisen [1–3]. According to largely accepted view, students learn to carry out engineering tasks quite well, but they do not necessarily learn to think. One the most famous advocates of such ideas is Derek Bok, a former president of Harvard University [4, 5]. In engineering, the roots of higher learning mainly evolve from thorough understanding of fundamentals, and consequently, from the ability of exploiting abstractions to tackle tangible problems. Furthermore, recent study from MIT concluded that achieving excellence in engineering education calls for "a coherent and interconnected curriculum structure" [6]. In this

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paper, we promote higher learning by suggesting a coherent method for structural development of substance in engineering education.

The balance between immediate and long-term skills is an endless dilemma in engineering education. In order to offer students important engineering skills appreciated in various tasks of industry, the toolbox of an engineer is filled with different designing tools, rules, standards and measurement procedures. These mainly constitute immediate skills in engineering education. They are certainly important, but they also have a downside: their validity may expire over the technological development. In order to also gain more profound understanding and readiness for changes in rapidly evolving industry, careful and time-consuming learning of fundamentals is required. These mainly constitute long-term engineering skills, or even permanent engineering skills, since their feasibility is not affected by the changes of technology. According to generally accepted view, the development of immediate skills in engineering education has quite successfully followed the changes in technology during the recent decades. However, we suggest that this has not been the case with long-term engineering skills. Especially in the economic pressure of current millennium, engineering education has excessively tilted towards immediate skills. Hence, we suggest that changes in engineering curriculum have not promoted a sustainable development of long-term skills during the most recent decades.

Recently, we presented the principles of a method to promote higher learning in higher engineering education [7]. In addition, as a case study, we have also shown how the method of cornerstones is implemented to clarify and to deepen the learning of circuit analysis in electrical engineering [8]. In this paper, we take a more general view on the subject to develop the whole field of engineering education by means of method of cornerstones.

2 Method of Cornerstones

2.1 Background

In order to have a systematic way to promote higher learning in engineering education despite the economic pressure, the method of cornerstones was created. In fact, the goal is twofold: (1) to clarify the content of immediate engineering skills, and (2) to give students a clear view towards deeper comprehension and long-term engineering skills. The method is enabled by hierarchical structure of natural sciences, since the fundamental rules of modelling on a certain level of concretization are only made up from the ones on the lower level of higher generality. Immediate engineering skills mainly arise from the identification and utilization of these fundamental rules. This gives a great opportunity to clarify the substance in engineering education. Furthermore, long-term engineering skills are closely related to understanding the assumptions validating the fundamental rules on a certain level of concretization. We will clarify these ideas in the following chapters.

According to our experience, some fields of engineering have already drifted quite far away from their roots. To be precise, in some specific and narrow fields of engineering, even professionals do not necessarily know where their models originate from.

Thus, they are not aware about the concretization of the models they are using. As a consequence, harmful shortcuts in education may come out. Although these are only cautionary examples, yet they make us worried about such progress becoming more common. Luckily, these problems can be avoided by recognizing the concretizations and identifying the cornerstones of modelling.

2.2 Implementation of Cornerstones on Engineering Education

The method of cornerstones rises from the hierarchical nature of science, Fig. 1. Although the all-encompassing theoretical framework of physics, the theory of everything, still remains incomplete, it inevitably seems that all the fields of engineering fundamentally rise from the same foundation. In fact, the recent discovery of gravitational waves is yet another step towards the final goal [9]. As we approach the theory of everything in any field of engineering, generality increases. And as a consequence, different fields of engineering resemble each other more and more. The circles in Fig. 1 represent different levels of modelling, or more precisely, different levels of concretization. When we recede from the theory of everything, level of concretization increases, since more and more details get fixed. And at the same time, generality decreases. Each level of concretization includes a set of fundamental rules of modelling, which we call cornerstones. They are marked with dots in Fig. 1. Thus, each level of concretization has a set of cornerstones, which lay the foundation for modelling there.

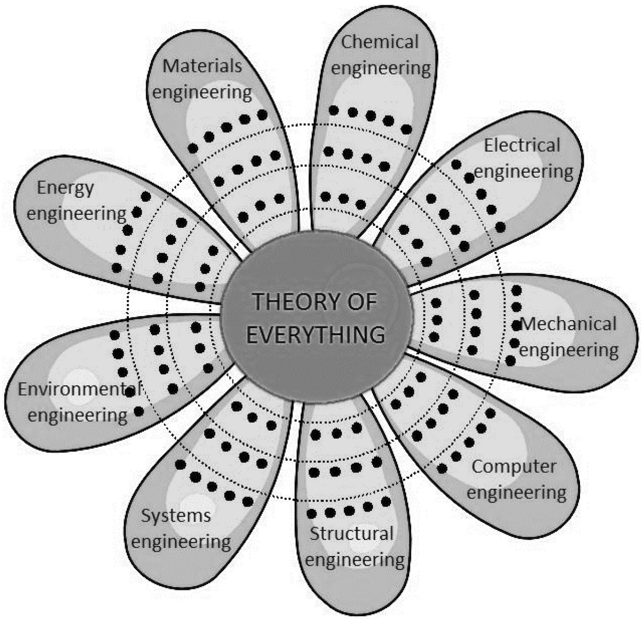

Fig. 1. Hierarchical structure of natural sciences.

The fundamental educational idea in the method of cornerstones is to make the structure of Fig. 1 visible to students. Then, this structure will be utilized in education by positioning courses on this road map of engineering substance. This is the main idea behind the coherent and interconnected curriculum structure that we are trying to build with the method of cornerstones.

2.3 Clarification of Immediate Engineering Skills

To make things more concrete, let's look at an example course of engineering, Fig. 2. In engineering education, we are always located on a certain level of concretization, and consequently, we always possess a certain set of cornerstones. Typically, the substance of an engineering course comprises different methods of modelling, which are utilized in real-life problems. Thus, from this point of view, Fig. 2 can be thought to represent a typical and maybe a bit simplified substance for a single course in engineering education.

Since the emphasis of engineering is on getting devices and systems to run, it is important that engineering degrees include a fair amount of immediate tools. They are highly appreciated in versatile tasks of industry, and due to them, engineers possess extensive toolboxes to solve many kinds of engineering problems. Usually, immediate engineering skills mostly arise from the ability to utilize different methods of modelling. These important contents of engineering toolboxes are depicted in the right side of Fig. 2.

But how do we clarify immediate engineering skills by means of the methods of cornerstones? The answer lies in identifying the cornerstones on each level of concretization. It is important to understand that different methods of modelling only rarely represent independent rules. Instead, they should rather be considered as different ways to apply the same cornerstones. In this way students are given a possibility to realize how different methods of modelling originate from the cornerstones. Consequently, after identifying the cornerstones and realizing the foundation of different methods of modelling, students are given much clearer overall picture of the engineering substance in question.

Figure 3 presents a concrete example of clarifying immediate engineering skills by means of cornerstones. This example is from electrical engineering, since Fig. 3 represents the house of resistive dc circuits. It stands on three cornerstones, and it includes many different methods of modelling. After the implementation of this course in technical university, a common personal feedback from students used to be often dealing with the confusion related to a great amount of different methods to analyze

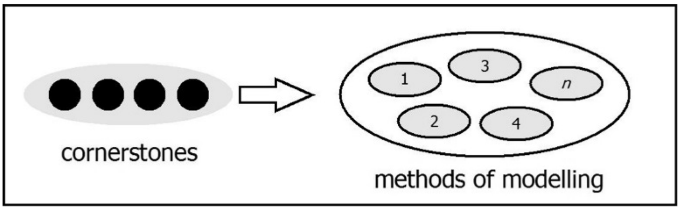

Fig. 2. Structure of one example course.

electric circuits. According to students, benefits of different methods easily remain unclear, and it is often difficult to see, which method is the most suitable for a certain circuit. However, by utilizing the idea of cornerstones the problem of multiple methods dissipates, since all the different methods arise from the same cornerstones. Thus, all the different methods can just be seen as different ways to apply the same cornerstones. In this way, students are given an opportunity to understand that the justification of existence of different methods mainly comes from finding the most efficient way (the smallest number of equations) to solve the problem. This is the idea in clarifying the content of immediate engineering skills by means of the method of cornerstones. First the cornerstones are recognized, and then, different methods of modelling, which usually comprise immediate engineering skills, are derived from the cornerstones.

2.4 Promoting Higher Learning and Long-Term Engineering Skills

Learning of immediate engineering skills typically occurs without questioning the validity of cornerstones. As repetition and routine are important means in learning to effectively utilize different methods of modelling, cornerstones are then usually taken as unquestioned rules. However, if we want to promote higher learning and long-term engineering skills, the validity of cornerstones has to be questioned.

Majority of long-term engineering skills arises from a thorough comprehension of fundamentals. Consequently, in the pursue of higher learning, we need to look underneath the cornerstones. Then, instead of unquestioned rules, cornerstones are seen as testable properties. That is, we try to give students an impression about the

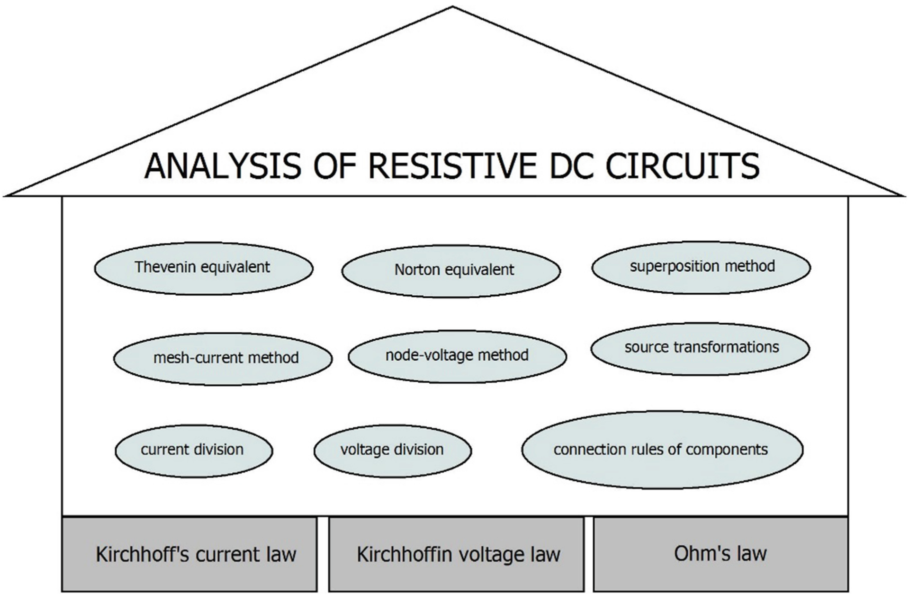

Fig. 3. Cornerstones and methods of modelling in resistive circuit analysis.

assumptions validating the cornerstones. And this is where the role of a teacher becomes especially important, since we need to look at more general levels of concretization, which typically are unknown or even frightening to students. Thus, a teacher has to be able to use a familiar language while introducing the topics on the lower level of concretization. Usually a mathematical representation is not a familiar one. Hence, in order to give students a clear impression about the assumptions validating the cornerstones, deeper content knowledge of a teacher is called for.

A concrete example of the assumptions validating the cornerstones can be seen in Fig. 4, which presents two levels of concretization in electrical engineering. The higher level in Fig. 4 represents the same substance as resistive dc circuit analysis in Fig. 3. As already mentioned, when learning immediate engineering skills related to different methods of modelling, cornerstones are typically taken as unquestioned rules. However, in order to understand the restrictions behind these methods of modelling, we have to treat the cornerstones as testable properties. Thus, we need to understand how the three cornerstones of resistive dc circuit analysis in Fig. 4 are derived from the five cornerstones of more general level of concretization. For example, in Fig. 4 Kirchhoff's voltage law (a cornerstone on the higher level) is based on Faraday's law (a cornerstone on the lower level) with the assumption that the magnetic flux density through a closed loop does not vary with time. We are not going into more details of deriving the cornerstones in this paper, but instead, we only want to emphasize that this kind of fundamental understanding mostly comprises long-term engineering skills.

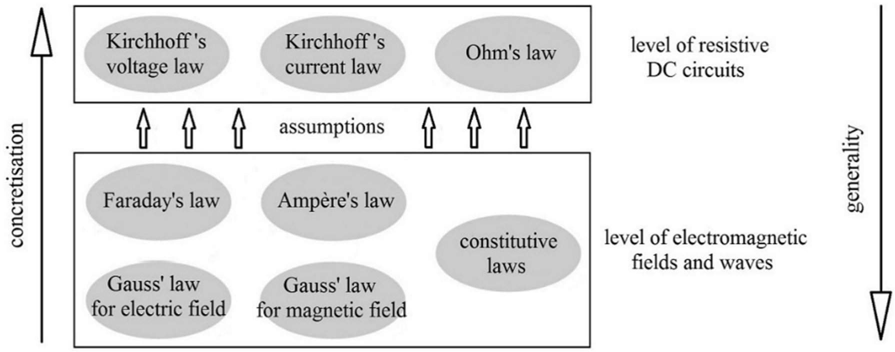

Fig. 4. Cornerstones of modelling on two levels of concretization in electrical engineering: cornerstones on higher level of concretization can always be derived from the ones on lower level.

3 Coherent and Interconnected Structure in Engineering Education

In a recent study carried out at Massachusetts Institute of Technology, Dr Graham ended up to conclude that "excellence in engineering education calls for coherent and interconnected curriculum structure" [6]. In this paper, we suggest that by extensively utilizing the method of cornerstones, such curriculum structure can be created.

As depicted in Fig. 1, in principle all the fields of engineering have the same kind of structure. However, as the theory of everything still remains incomplete, the strengths of fundamental theories behind different fields of engineering vary. For example, electrical and mechanical engineering are the ones with the strong fundamental theory. On the other hand, for example the fields related to biological engineering do not have equally strong fundamental theory, since science of today is not yet able to unambiguously model living organisms. However, the lack of strong fundamental theory doesn't necessarily significantly hinder the utilization of method of cornerstones. Instead, it may provide a transparent method to organize the substance and to recognize the shortages of unambiguous modelling.

A principal and simplified structure of a single field of engineering is presented in Fig. 5. In this example, there are four different levels of concretization, and this structure could represent for example the electricity-related substance in the Master of Science degree of electric power engineering. Then, the lowest level of concretization would be the level of electromagnetic fields and waves, which was already presented in Fig. 4. Furthermore, as the level of concretization increases, there are different levels of circuit analysis, since the specialized models of electric power engineering are mostly based on circuits. The lowest levels of concretization in circuit analysis typically represent the modelling of circuit transients, and as concretization further increases, we are dealing with sinusoidal steady-state circuit analysis. The uppermost level of

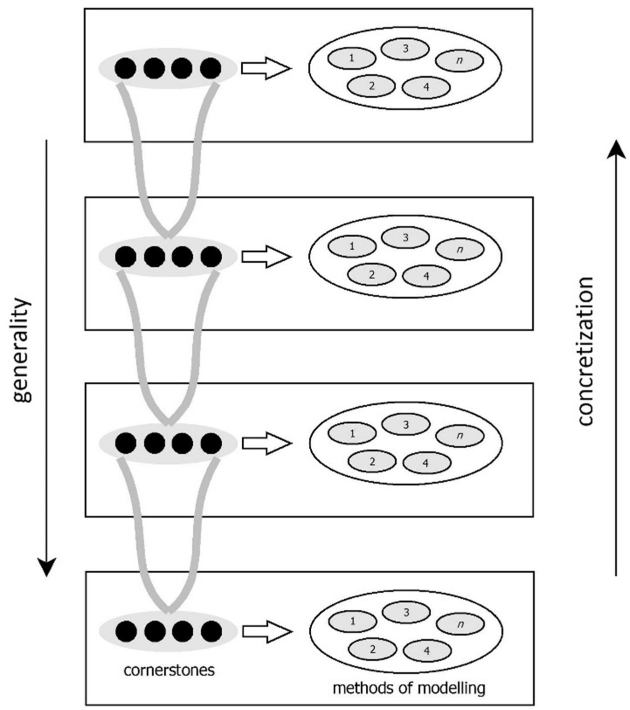

Fig. 5. Principal and simplified structure of a single field of engineering.

concretization could represent some narrow-field models of specialized studies, where more and more details get fixed. However, regardless of the number of levels, the most important idea in Fig. 5 is that all the substance related to electrical engineering can be positioned on this road map.

The structure presented in Fig. 5 repeats the more general one presented in Fig. 1. On each level of concretization, immediate engineering skills mostly arise from the ability to utilize different methods of modelling. And furthermore, long-term engineering skills are mostly achieved by understanding, how the cornerstones arise from the ones on a more general level. This is also depicted in Fig. 5: cornerstones on the higher level of concretization can be derived from the ones on the lower level.

The fundamental idea in creating coherent and interconnected curriculum structure by means of the method of cornerstones is (1) to make the structure in Fig. 5 visible to students and (2) to position each course of engineering substance on this road map. We suggest that when substance of engineering education is organized in this way, students are able to get a clear and profound overall picture of the engineering field. Furthermore, the road map gives students a clear view towards deeper comprehension. For example, if some specific method of modelling gives significantly different results than the measured ones, problem probably lies in the assumptions validating the cornerstones.

By further extending the application of method of cornerstones, we end up to a structure presented in Fig. 6. As already mentioned, although the strengths of fundamental theories behind different fields of engineering vary, the same kind of a structure can still be found in any field of engineering. We suggest that by utilizing this structure in engineering education, we finally end up to have a coherent and interconnected curriculum structure, such as Dr Graham recently called for.

The structure presented in Fig. 6 would offer great advantages for students, but also for teachers. For example, when students are studying secondary subjects of their engineering degree, they would confront the same kind of structure as in their major subject. They would learn what are the cornerstones in other fields of engineering, and due to the coherent and interconnected structure, they would attain quite extensive overall picture of engineering fields. In fact, actual interconnectivity comes from

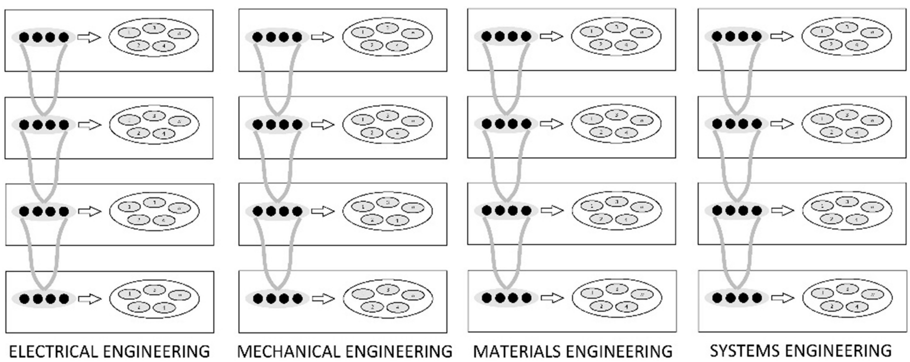

Fig. 6. Principal structure of substance in different fields of engineering.

understanding that different fields of engineering resemble each other more and more, as we move towards lower and lower levels of concretization. As an example from electrical engineering, it is not really possible to understand other fields of engineering by means of circuit analysis. But if we understand more general level of electromagnetic fields and waves, it will already give quite good premises to understand for example mechanical engineering.

If the substance of engineering education is arranged according to the principles presented in Fig. 6, we suggest that the coherent and interconnected structure demanded by Dr Graham will be achieved. Although a comprehensive road map including all the fields of engineering is probably unattainable at the moment, even incompleteness of the map doesn't erase its benefits. Instead, it promotes openness and transparency.

4 Discussion

The dilemma between immediate and long-term skills in engineering education is more or less endless. Immediate engineering skills are highly valuable, since the emphasis of engineering is on getting devices and systems to run. On the other hand, it is clear that competitive R&D cannot rely only on immediate engineering skills. Instead, a more profound approach and long-term engineering skills are also required. In addition, since the validity of some immediate engineering skills may expire over the technological development, long-term skills offer readiness for changes in rapidly evolving industry. With the method of cornerstones, we aim to clarify the interconnected roles of immediate and long-term engineering skills. By drawing a comprehensive road map of a specific field of engineering, students are given an opportunity to get a clear view about the substance. Each level of concretization has its own cornerstones, from which different methods of modelling, and thus the majority of immediate engineering skills, are built from. Furthermore, long-term engineering skills mostly arise from looking underneath the cornerstones and understanding their premises. Then, instead of unquestioned rules, cornerstones are seen as testable properties. This kind of substance-oriented approach also enables a transparent development of engineering education, since all the engineering substance can be positioned on the road map. We suggest that there are no shortcuts in achieving deeper comprehension. And as a result of utilizing the method of cornerstones in engineering education, we might really get graduates that, with the description of Derek Bok, have "learned to think" [4].

In Finland, in the city of Tampere, a nationally exceptional project called Tampere3 is carried out at the moment. The idea is to form a union of three independent universities in the town. As such, a project to join universities is not a unique one, but the exceptionality of Tampere3 rises from the fact that a university of applied sciences is also involved. The goal is to combine Tampere University, Tampere University of Technology and Tampere University of Applied Sciences into one wide-ranging university and to offer students exceptionally wide opportunities for studying.

In this paper, we will not discuss Tampere3 project any further. However, an interesting detail is that the method of cornerstones has been chosen as one educational development pilot in the project. In the first phase this means that the method of cornerstones will be utilized, when the substances of electrical engineering in Tampere University of Applied Sciences (Bachelor of Engineering) and Tampere University of Technology (Master of Science) will be thoroughly scrutinized. The first aim is to draw a detailed substance road map of electrical engineering. Then, each course of electrical engineering from both universities will be positioned on the map. By means of method of cornerstones, we aim to carry out a substance-oriented union of electrical engineering education in Tampere3 project.

In Finland, the scientific subjects, such as mathematics and physics, are at the moment so unpopular among young people that some kind of national concern has already risen. In general, youths find these subjects so difficult already in elementary school and later in high school that the beauty of scientific subjects never really reveals to the majority of pupils. We suggest that also the popularity of scientific subjects could be promoted with the method of cornerstones. When the same road map with the same cornerstones is utilized from the scratch of scientific studies in elementary school, the whole field of engineering doesn't anymore appear messy and frightening. Instead, in the best case, it appears fascinating and logical.

Finally, the method of cornerstones also enables a systematic and transparent tool for continuous development of substance-related proficiency. This is especially useful for teachers, since drawing of unambiguous road map is not easy at all, not in any field of engineering. But during the years the missing connections between the cornerstones of different levels probably complete, at least partly, and as a consequence, a teacher has a stronger and stronger foundation to teach the substance. In the end, it has to be remembered that the individual development of proficiency in natural sciences is always an endless process.

5 Conclusions

In this paper, by means of the method of cornerstones, we aimed to present a coherent and interconnected curriculum structure in engineering education. The method is enabled by hierarchical characteristics of natural sciences, since the cornerstones of modelling on a certain level of concretization only arise from the ones on a lower level. The initial goal was two-fold: 1) to clarify the content of immediate engineering skills, and 2) to give students a clear view towards deeper comprehension and long-term engineering skills. Immediate engineering skills are promoted by recognizing the cornerstones on each level of concretization, and by applying the cornerstones to build different methods of modelling. Long-term engineering skills mainly arise from looking underneath the cornerstones on a certain level of concretization. Then, instead of unquestioned rules, they are seen as testable properties. Thus, in order to gain more profound understanding, we need to understand the assumptions validating the cornerstones. In this way, students are offered better premises for higher learning and long-term engineering skills.

In this paper, the building of coherent and interconnected curriculum structure was started by recognizing the cornerstones on a single level of concretization. Then, the cornerstones were used to build different methods of modelling. Next, different levels of concretization in a single field of engineering were recognized. In fact, after recognizing the different levels of concretization, a comprehensive road map of one engineering field arises from finding the connections between the cornerstones of different levels of concretization. This structure is unambiguous only in some fields of engineering, but still, we suggest that this problem doesn't significantly hinder the utilization of the method of cornerstones in engineering education. Regardless of the field of engineering, the idea is to present the substance as organized and interconnected as possible in order to give students better opportunities to achieve substance-related excellence in engineering. The final goal is to have a comprehensive road map of engineering that can be utilized in every level of academy; from elementary school to university. Furthermore, the method of cornerstones also enables a systematic and transparent tool for continuous development of substance-related proficiency. This is especially useful for teachers, who continuously develop the substance of their courses year by year.

As a long-term goal, we aim to develop and to promote scientific subjects in Finnish academies. The first step is to utilize the method of cornerstones in Finnish Tampere3 project, where one wide-ranging university is combined from three independent universities in Tampere. The method of cornerstones has been chosen as one educational development pilot to organize the substance of electrical engineering for new university.

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SLA as a Vital Part of Continuous Professional Development Among Academics

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Abstract. During recent years, Russian universities have demonstrated intention to get integrated into international education and research. One of such universities is National Research Tomsk Polytechnic University (hereafter TPU). Achievement of this goal requires a perfect level of English proficiency among TPU academic staff. This fact gave birth to a new direction in the work of TPU EFL teachers – searching for ways of improving English proficiency among TPU academics. A research devoted to this problem is being conducted in TPU. Before starting the main study, a group of researchers initiated a pilot survey to get an overall state of the problem. So, the paper involves literature review, deals with the results of the pilot survey covering TPU academics' perceptions on language learning. Along with that, conclusions are formulated and further steps are outlined.

Keywords: Academics · Adult learning · Continuous professional development · Lifelong learning · Second language acquisition · Metacognition

1 Introduction

The strive for international integration in Russian academia is especially typical of engineering universities, as it provides effective engineering training, development of new innovative ideas and creation of resource-efficient technologies. Turning to TPU, its main goal is to provide university advancement in the areas of education and research, in sustainable development of academic and scientific resources, which support high-technology sector of economy at the level of the most advanced world standards. These targets prove the need of international collaboration and, consequently, a perfect level of English proficiency.

We believe that second language acquisition (hereafter SLA) among TPU academics is a complex, multi-dimension phenomenon involving various aspects of such areas as adult learning (hereafter AL) and continuous professional development (hereafter CPD), which should result in the ability for lifelong learning (hereafter LLL). Thus, we are starting a short review to investigate the interrelation of the areas mentioned and identify further research route.

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2 Literature Review

2.1 Adult Learning

Compared to younger students classroom, in which knowledge and status asymmetries are taken for granted, adult learners bring to the classroom life experiences and professional expertise, which potentially render them more or less ‘equals’ of the instructor in many respects, with the exception of the domain of the second language.

It is Malcolm Knowles, who proposed a theory of AL called andragogy, centered on the differences between how a mature adult and how a child learn (cf. Armstrong 2015). According to Knowles, some of the characteristics of a mature learner are self-directedness; accumulated life experience, which becomes a resource for learning; readiness to learn oriented to learner’s social roles; orientation to learning focussed on problem application rather than subject focused; internal motivation to learn and the need to know why something is being learned (Knowles 1984). In addition, Lawler states such aspects of AL as student anxiety; student expectations; student experience; participation; lessons relevant to student needs; student growth (Lawler 1991). So, AL is a starting point for adult growth and further development.

2.2 Continuous Professional Development

CPD is doubtlessly important for academics to improve the quality of their teaching and their students’ learning. As a professional, you have a responsibility to keep your skills and knowledge up to date. CPD helps you to turn that accountability into a positive opportunity to identify and achieve your own career objectives.

In fact, CPD is a combination of approaches, ideas and techniques that will help you manage your own learning and growth. The focus of CPD is firmly on results – the benefits that professional development can bring you in the real world (Harwell 2003).

The key features of CPD are as follows: being a documented process; being self-directed: being driven by yourself; focusing on learning from experience, reflective learning and review; setting development goals and objectives; including both formal and informal learning (Butler 2004).

Training and development has a difference in use. These terms are often used interchangeably, though there is a distinction. As a rule, training is formal and linear. It deals with learning how to do something specific, relating to skills and competences. Development is often informal and has a wider application, giving you the tools to do a range of things and relating to capability and competency. It involves a progression from basic know-how to advance. Alternatively, it can be about widening your range of transferable skills like leadership, managing projects or organizing information (Schostak 2010).

All in all, the crucial benefits of CPD are aimed to expand the ‘learning agility’ as a core competence of metacognition. We truly believe that CPD is a meaningful step to a higher ‘floor’ – LLL, which becomes the final goal in professional development.

2.3 Lifelong Learning

LLL is more than training or continuous education. It must support multiple learning opportunities, including exploring conceptual understanding as well as narrowing knowledge to practical application, ranging over different settings such as academic education, informal learning, professional and industrial training (Vargas Zuñiga 2005).

LLL, as it has been described, is a set of organizational and procedural guidelines for educational practice. It is important to make clear at once that what is meant by "learning" is not the day-to-day learning. It is perfectly clear that such learning is lifelong – the kind of learning that is the object of education called "deliberate learning" (Popescu 2011).

Proponents of LLL emphasize, among other things, that a system of lifelong education deals predominantly with adult clients, simply because in the normal course of events most people spend far more of their life as adults than children or adolescents. Thus, the principle of LLL has important consequences for adult self-education. This does not, however, mean that LLL is simply another way of saying AL. It is learning which is considered to extend the values and methods of systematic provision of learning opportunities during the entire lifetime (Aspin 2000).

3 Metacognition

A great number of researches exploring AL, CPD and LLL put a great emphasis on metacognition as a vital ingredient leading to efficiency in adult education. Why is metacognitive knowledge significant for learning? Wenden (1998 p. 520) summarises that metacognitive knowledge characterises the approach of expert learners to learning, that it enhances learning outcomes, facilitating recall, the comprehension of written texts, the completion of new types of learning tasks, and that it improves the rate of progress in learning as well as the quality and speed of learners' cognitive engagement (cf. Öz 2005, p. 151). Furthermore, in Joseph's words "this introspective ability is important because it produces the powerful knowledge that enables students to control their learning by demonstrating a conscious application of cognitive strategies" (2003, p. 151).

According to Livingston (2003), metacognition is a complex of phenomena related to knowledge about cognition (thinking, knowing, remembering) and its regulation. Today, the conceptualisation of metacognition in educational sciences and language teaching is often attributed to John Flavell. According to Flavell (1979), "metacognitive knowledge consists primarily of knowledge or beliefs about what factors or variables act and interact in what ways to affect the course and outcome of cognitive enterprises" (1979, p. 907).

Wenden (1998, p. 528) considers metacognitive knowledge as "a prerequisite for the self-regulation of learning: it informs planning decisions taken at the outset of learning and the monitoring processes that regulate the completion of a learning task…". It is necessary to note that Flavell (1979) divides metacognitive knowledge into three categories: person knowledge; task knowledge; strategic knowledge.

In fact, researchers' perception of metacognition has also influenced language learning (Lamb 2001, 2000, 2000; Oxford 1990; Wenden 1987; Wenden 1998; Wenden 1991; Victori 1995). According to Flavell (1979, p. 907), "metacognitive knowledge has a significant role in many cognitive activities concerning language use, e.g. oral communication of information, oral persuasion, oral comprehension, reading comprehension, writing; to language acquisition; and to various types of self-instruction". If language teachers wish to influence leamers' attitudes and behaviours, they will need to address the underlying beliefs on which they are based (Benson and Lor 1999; Joseph 2003; Livingston 2003; Öz 2005; Wenden 1987; Wenden 1991). Now, there is no doubt about the importance of metacognitive knowledge for adult language acquisition.

4 Methodology

Turning to our research, we think that qualitative research is more appropriate in social sciences than quantitative, as it aims to get a complete and detailed description of reality perceptions (Crotty 1998; Roberts 2004). So, our research is situated in two traditions, that of epistemology and ontology. In short, ontology deals with our assumptions of reality and social world. We agree that no absolute truth or knowledge exists, this can be explored through human beliefs, perceptions, and their experiences in a social context, thus taking a constructivist view (Bryman 2008; Crotty 1998; Snape & Spencer 2003; Richards 2003).

Epistemology is about the nature of knowledge and how it can be acquired (Bryman 2008; Crotty 1998; Richards 2003; Snape & Spencer 2003). From our opinion, researcher and social world are interrelated and interconnected. S/he cannot distance her/himself from the research process but gets involved in the process along with the participants (constructs interpretations and meanings with regard to own reflections and experiences). Knowledge acquisition is a process dependent on a learner and his/her specific context implying active interaction between individuals, which can be best explored through the eyes of different participants. For this reason, we turn to interpretivism. As for the methods used, at the present stage of our research they are reflection and questionnaire.

5 Results

For the pilot survey, a questionnaire determining TPU academics' perceptions of language learning was developed. 20 members of TPU academic staff, specializing in power engineering, participated in the survey (8 professors, 12 associate professors). We found out that TPU academics studied English either for professional or personal reasons. They had different learning styles, but few participants were aware of these characteristics. As for the biggest language learning challenge for the respondents, lack of active vocabulary, listening, speaking, weak grammar and lack of language environment were mentioned. In addition, questionnaire analysis revealed disability to manage own learning and a certain level of foreign language anxiety among the participants manifested in the worry and usually negative emotional reaction aroused when learning or using English. The level of motivation was medium.

6 Conclusion

Literature review demonstrated interrelation of AL, CPD, and LLL. The findings of the survey based on questionnaire are valuable both, for learners and teachers, giving the necessary background for main research. The survey results led to the conclusion that learners' needs, goals and perceptions about language learning should be taken into account, thus increasing their motivation in learning. Along with that, learners' and teachers' perceptions in terms of potential constraints and affordances, curriculum and pedagogy are of high value.

From now, we wonder what is it the defensible curriculum that should be offered to TPU academics as a part of an English CPD course? Overall, the intention is to build up a comprehensive picture of language learning and teaching as construed by the learners and teachers in order to allow a thorough exploration of the EFL process in TPU, determine the perceived gaps between what is being delivered versus what might be sought, and design a curriculum legitimate in this specific context. The data obtained can become a potential gateway to design a CPD course of English, enabling effective SLA among TPU academics, helping them to become better researchers and provide skills for LLL throughout their career.

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Innovations in Enterprise Informatics Subjects

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Abstract. As latest knowledge and skills are required from technical and engineering graduates, innovations made in curricula at the FIM UHK are briefly introduced. Moreover, students' visit rate to online courses supporting the subjects was monitored and correlated to evaluation of their final knowledge in three selected subjects. The results show that statistically significant correlation was detected in Enterprise Informatics I. Numerous practical activities are included in the learning content of this subject, students conduct them online, and this fact increases the visit rate to the online course.

Keywords: Software engineering · Enterprise informatics · e-learning · Success rate · Visit rate Tracking

1 Introduction

Reflecting the proposals of practitioners from IT companies, innovated curricula have been implemented in all study programmes at the Faculty of Informatics and Management (FIM), University of Hradec Kralove (UHK) so as to develop appropriate professional competences of technical (bachelor) and engineering (master) graduates to succeed on the labour market [1].

The process of innovations started by assessing the current curricula by the HIT Cluster (Hradec IT Cluster), i.e. by the society of important IT companies in the Hradec Kralove region, and by the Faculty Study Programme Board [2]. They both aimed at creating a set of multidisciplinary courses, seminars and online practical exercises to develop students' theoretical knowledge and practical skills. Subjects in each study programme are structured into five groups – Data Engineering, Computer Networks, Software Engineering, Knowledge Technologies and Enterprise Informatics; the last one is under the focus of this paper [3]. Therefore, the main objective of this paper is (1) to introduce curricular changes and (2) to discover whether there exists any correlation between the visit rate to the online courses supporting the face-to-face instruction and students' success rate in the subjects.

2 Innovations in the Group of Enterprise Informatics Subjects

Rather wide and deep knowledge of all five groups of subjects is expected from the graduates of Computer Science study programmes at FIM. The courses of Enterprise Informatics were included in the curricula of bachelor and master study programmes of

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Information Management and Applied Informatics more than 15 years ago. The group consists of following subjects: Applied Information Technologies; E-technologies for Business and Entrepreneurship; Project Management; Presentation Skills; Introduction into Enterprise Informatics; Enterprise Informatics I, II; Management supporting Systems I, II and Designing Professional Texts.

2.1 Employers' Requirements on Graduates

The requirements on technical and engineering FIM graduates' knowledge were defined by the expert group consisting of 11 members of the HIT Cluster. The process was conducted in following steps. First, the original state was analyzed by the experts. Second, a new concept of subjects was proposed. The process of face-to-face instruction in each subject was supported by an online course in the Learning Management System (LMS) Blackboard; each online course was equipped with didactic instructions, study materials, tests and communication tools [4].

The expert team was headed by the vice-dean for study affairs. The team defined following general obligatory graduates' competences to be reached: high level of creativeness in task-solving; good knowledge of English (both oral and written); ability to work in team and communication competence. Specifically, in the field of Enterprise Informatics, the graduate should be able to understand the multi-disciplinarily of Enterprise Informatics and apply it through a wide spectrum of subjects in this field.

2.2 Innovative Contents in Single Subjects

As listed below, following learning objectives and innovative design and contents were included in the innovated syllabi. The subject of *Applied Information Technologies* (AITE) aims at developing students' knowledge on the advanced use of text editors. First, students learn how to design and administer large template-based text documents and format them according to typographic principles. Second, students learn how to adjust and analyze data organized in tables or lists and present them in a graphical form. Within *E-technologies for Business and Entrepreneurship* (ETBE) the main objective is to form a map of current state of e-technologies and provide students basic theoretical knowledge on how e-technologies can be applied in e-business and e-commerce. In *Project Management* (PM) students apply principles of both the independent and team work, they play various roles within the division of labour, synchronization of all activities and meeting deadlines. In *Presentation Skills* (PS) students should acquire theoretical aspects of designing presentations, psychological aspects of their exploitation and the ability to work with information in such a way so that they provided relevant (i.e. short, simple, clear, interesting) message. Introduction into *Enterprise Informatics* (ItEI) is the first of three subjects developing students' knowledge and skills in this area; Enterprise Informatics I and II (EI I, EI II) follow. Starting from the basic information students step by step acquire various software systems which support single company activities and processes. In follow-up subjects students acquire the information systems management and selected aspects of

Enterprise Informatics. The emphasis is paid on the optimization of the Enterprise Informatics management through exploitation of tested methodologies, standards and best practices. In the subjects of *Management Supporting Systems* I and II (MSS I, MSS II) students learn how to apply basic decision-supporting methods, theoretical background and application potential, as well as to identify the decisive problems and design their solution with the use of appropriate methods and software. Similarly to previous subjects, the emphasis is paid on practical application of new knowledge and skills, including the knowledge of latest trends, concepts and technologies supporting the sharing of information, co-operation, communication and visualization. How to write seminar works and bachelor/diploma theses with the use of formatting tools and typographic principles is the main objective in the subject of *Designing Professional Texts* (DPT).

2.3 E-Learning Support to the Subjects

Each subject of this group is enhanced by an online course in the LMS BlackBoard [5] which has been used at FIM since 2001. Guiding instructions, study materials, assessment tests and communication tools (e-mail, discussion) are available to students. Study materials were developed not only as standard presentations; they contain audio-visual materials, animations and instructional video-recordings which can be easily update. Students' attendance in the courses and lectures is monitored in order to evaluate the results of the individual tests, reflect students' activity and detect the fields of students' interest. When smart mobile devices penetrated the Czech market, students' work in courses changed substantially because all the learning content and tools could be also available on the smart mobile devices and smart education mechanism started to work as an integrated educational environment in which co-operative, interactive, participative, shared and intelligent learning are available through new forms of teaching/learning content, environment and ICT.

2.4 Expert Evaluation of Subjects

The evaluation of the group of Enterprise Informatics subjects was made by companies joined in the HIT Cluster, particularly by ORTEX, GIST and DERS companies.

Experts had both the complex information available on innovated subjects and access to online courses within the LMS BlackBoard. The evaluation process was conducted through the questionnaire consisting of 25 statements. Experts' opinions, i.e. their dis/agreement with the statements, was expressed on the four-level Likert scale (agree – partially agree – partially disagree – disagree). Moreover, they could add any comments to each area in the form of open answers. Totally 18 evaluation reports were provided for the group of Enterprise Informatics subjects. The results can be summarized as follows:

- Learning objectives and measurable outputs were clearly defined. They reflected the requirements of the labour market on graduates' knowledge and skills. They were displayed to students on several places within each online course.

- The pre-defined learning objectives were reflected in the learning content. It was presented in logical order and structured into appropriate modules; multimedia elements were connected to appropriate parts and chapters. Finally, deeper understanding of the learning content explained via practical examples and best practices is expected from the students.
- Each online course contains the didactic instruction (student's guide) on how to study the subject effectively.
- Clear assessment criteria are displayed to students in each online course.
- Sample semestral projects and tests relate to the pre-defined learning objectives.
- Questions of various types, projects, discussions etc. are applied for testing students' knowledge. Students also have self-evaluation tools available which give them immediate feedback on their knowledge.

3 The Success Rate in the Subject Versus the Visit Rate to the Course

The research question was whether there exists any correlation between students' visit rate to the online course supporting each subject and their final success in the subject (i.e. whether they met the requirements and successfully passed the subject). In other words, we researched whether students were more successful in passing the subject, if they more frequently accessed the course (i.e. if more hits to the course were detected). Or, did the learner's low frequency of visits to the course (i.e. lower amount of hits) correlate to poor study results, i.e. to failing the course?

Three subjects from the group of Enterprise Informatics were selected as examples – Applied Information Technologies (AITE), E-technologies for Business and Entrepreneurship (ETBE) and Enterprise Informatics I (EI I). All courses were taught for 13 weeks, and as mentioned above, all subjects were supported by online courses in LMS Blackboard. The LMS provided tracking services, so it was easy to collect data on students' performance in the online courses.

The collected data were structured as follows:

- Students' success in the subject, i.e. whether students successfully passed the subject, or they failed (Fig. 1);
- frequency of hits of successful and failed students and final result of correlation between the success rate and visit rate to the online courses (Table 1);
- correlation between the success rate (i.e. student's final grade from the subject) and the visit rate (i.e. amount of hits) to the online courses (Fig. 2).

Totally 467 students enrolled in the subject of AITE; 192 of them successfully passed the course; in ETBE 73 students participated and 54 successfully passed the subject; in EI I 159 respondents studied this subject and 125 of them successfully passed. Results in percent are displayed in Fig. 1.

In Table 1 descriptive characteristics collected from the three online courses are presented, been structured to passed and failed students.

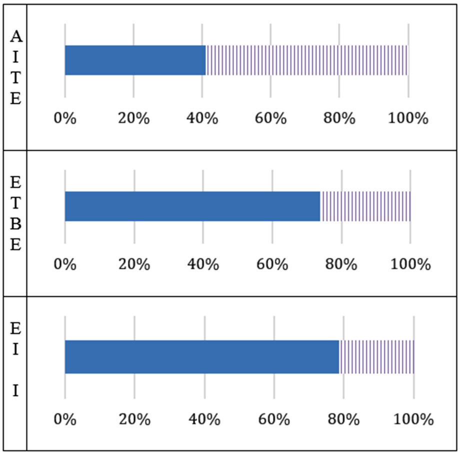

Fig. 1. Students' success in AITE, ETBE and EI I (full colour – pass, striped – fail) (left)

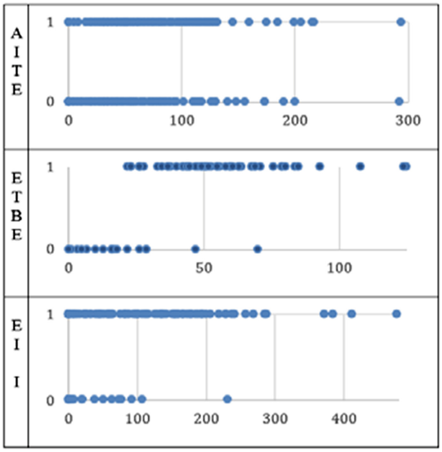

Fig. 2. Correlation between the success rate and visit rate to the courses (1 – pass, 0 – fail) (right)

Table 1. Descriptive statistics of AITE, ETBE and EI I courses

Hits (n)	AITE		ETBE		EI I	
	Passed	Failed	Passed	Failed	Passed	Failed
Mean	67.8	33.2	54.1	18.2	89.7	23.8
Min	0	0	22	0	0	0
Max	298	292	125	70	476	232
Median	54	21	52.5	16	58	0.5
R	0.324		0.062		0.035	
Significance	no		no		**yes**	

In AITE, whereas students who successfully passed the course, accessed the e-courses 68 times in average, the unsuccessful students who failed reached significantly lower frequency – their mean visit rate was 33 times. Similarly to this, the identical correlation was detected in medians (54 versus 21).

In ETBE, whereas the mean visit rate of successful students was 54, the unsuccessful students who failed reached three times lower frequency (18 times). The indirect correlation was detected in medians (52.5 versus 16).

In EI I, whereas the successful students accessed the online course 90 times in average, the failed ones 24 times only. Thus their visit rate was nearly four times lower. This correlation was strongly expressed in median values (58 versus 0.5).

Total data describing all students' (successful and failed) activities in the online courses are as follows. In AITE 41% of students successfully graduated from the subject. The visit rate was spread within the interval from zero to 298; the mean visit frequency of all students was 47.44; median 39. The data show that (in average) students accessed the course four times per week. In ETBE 74% of students successfully graduated from the subject, i.e. the success rate was much higher. The frequency of visit rate to the online course was different – it was spread within the interval from zero to 125; the mean visit frequency was 46; median 45. The data show that (in average) students accessed the course three times per week. In EI I nearly 77% of students succeeded in the subject, which is the highest rate of all subjects. The visit rate was spread within the interval from zero to 476; the mean visit frequency was 76; median 38. The data show that (in average) students accessed the course six times per week.

The correlation between the success rate and the visit rate to the online course is displayed in Fig. 2.

The collected data were processed by SPSS statistic software applying the method of regression analysis, when the correlation coefficient (R) was calculated. Results are displayed in Table 1 (Rcrit.: 0.05): R and Significance. The significant value was detected in the subject of Enterprise Informatics I (EI I) only. The average visit rate of successful students was the highest of all three subjects (89.7). The reason was that numerous interactive animations demonstrating single principles were included in the learning content of the online course. Moreover, they were supported by practical activities and tasks. Each activity/task was structured into several steps for easier comprehension, so it was not comfortable for students to download the study materials and work with offline version. Therefore, they accessed the materials online, each one for several times. That was the reason why the total visit rate to this course is so high. On the other hand, this result was supported by rather low visit rate of failed students (23.8). The largest difference in this subject was detected in medians. This result could be a reason of their failure (contrary to AITE and ETBE). Moreover, the learning content is much more demanding compared to other two subjects; it requires regular and deep work to be acquired.

4 Summary of Results, Discussions and Conclusions

As new requirements on technical and engineering graduates' knowledge and skills are continuously appearing, FIM UHK started the co-operation with local IT companies within the HIT Cluster. Both parties worked on evaluation of curricula. Reflecting the experts' recommendations, changes were made in the group of Enterprise Informatics subjects. To illustrate them, three subjects were selected where the visit frequency to the online courses supporting the face-to-face instruction was monitored and correlated to students' success rate in the subjects. The statistically significant result was detected in Enterprise Informatics I. The reason is the subjects contains a rather large amount of activities and tasks which students prefer to solve online, not offline. This approach increases the visit rate to the course and students' success rate in the subject is high.

From the view of technical and engineering education, following studies on innovations in the field of Enterprise Informatics should be mentioned. First of all, the meta-analysis by Peer and Penker [6] could be compared to the FIM situation. Authors also recommend to establish relations to regional environment with the aim to support the development of graduates' knowledge and skills. The FIM has applied a similar approach as it has been developing co-operation with the HIT Cluster for several years, as mentioned above. A higher-order structural model of innovations and entrepreneurship was designed by Lee et al. [7]. Various criteria were implemented in the model and tested. Within findings of this study important implications for industry authorities were discovered which were proposed for implementation into economic and engineering study programmes. Similarly to the FIM study, Kucel et al. [8] investigated entrepreneurial education and its impact on job-skills matches on higher education graduates. They discovered that graduates having entrepreneurial skills were (1) more market aware and creative in searching for job and (2) they also better considered whether the position matched their professional skill, or not. Menold et al. (2016) focused on the potential to transform engineering education through innovativeness. The understanding, evaluating and promoting individual innovativeness was considered to be a critical step in developing engineering leaders for the future [9]. For evaluation of the subject of Entrepreneurship in engineering education a tool was designed by Cunha et al. [10]. Authors aimed at identifying, explaining and evaluating the impact of the subject on students of Engineering and Computer Science (IT) and their development of technological innovations in companies. Thirty students were observed after graduating from the subject and the findings discovered a direct relationship of the graduates to the increased amount of technological innovations. The model integrating both the innovations and entrepreneurial principles in the engineering curriculum was designed by Beiler [11]. Reflecting the latest developments, the sustainability was integrated in the curricula of civil engineering students. The Kern Entrepreneurship Education Network (KEEN) Program was established to develop attitudes necessary for entrepreneurial activities with graduate engineers. The collected data indicate that there are existing strengths as well as future opportunities to enhance students' performance of innovative thinking and open-ended problem-solving skills that are essential to promoting sustainable design and development. Hug et al. [12] propose, in order to develop the engineers of the future, that engineering departments should embrace innovative, student-centered practices. The development and sustained growth of practices, which are necessary for improving the engineering education, depend upon the attention to human resources, leadership, knowledge development, revenue development and opportunities for continuous engagement. Therefore, curricular changes indicate that initial training and dissemination is necessary but not sufficient for this purpose. However, all changes require innovative practices. As stated by Besterfield-Sacre et al. [13] numerous studies have presented various proposals of what engineering education should look like. However, only few of them describe how this should be really done. Currently, a lot of emphasis has been paid on engineering education research (EER) and engineering education innovation (EEI). In the EER domain, several universities have established or are considering establishing engineering education research centers and PhD programmes. In the EEI domain, the National Academy of Engineering launched the Frontiers of Engineering Education (FOEE) symposium (its results are mentioned above) and more recently the Improving Undergraduate STEM Education (IUSE) [14].

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Contribution Studies of Engineering Alumni on the Quality of the End of Project Studies of the Following Promotions

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Abstract. The industry expressed expectations about future electromechanical engineers to recruit have greatly evolved in recent years. Now it is no longer to recruit an engineer who has theoretical knowledge-intensive and sit in a comfortable office, but rather to recruit an operational engineer very quickly and above all who will go on the field whenever there is a need to deal with all types of dysfunctions. This profile therefore requires expertise with strong practical components (technical and managerial knowledge). To meet this need, the classic approach widely applied in engineering schools is to book last semester courses in a graduation project (or internship) in which each student will process a concrete industrial problem within a business. Hence the importance of the end of study project in the course of an engineer. Now we notice, in recent years, deterioration in the quality of its graduation project either in substance or form. In this paper, we propose an approach that is simple, free and effective. Indeed, for a given module that processes multiple parts, it is to proceed in two steps. Firstly, we teach a given part by giving the essential theory and foundations. Secondly, we invite a recently graduated engineer (from our school) who has successfully validated its industrial project. This engineer will present during a session their main skills during the course related to that particular part of the module. Through this article, we show that this approach allows, among other things, to improve learning outcomes through: knowledge of the industrial's reality, the removal of purely theoretical notions in favor of targeted practical knowledge and improving the quality of graduation project reports (content and form).

Keywords: Internship · Recommendations · Industrial experiences · Former students · Talk

1 Introduction

In order to achieve the teaching mission of a university teacher, which consists in perfecting the theoretical knowledge of the student as well as his efficiency and his reactivity on fieldwork, it is necessary to give him the tools to concretize the information needed in his professional career. In the one hand, several industrial managers

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who receive our students either as interns or as recruits often reproached us that our students go into business without landmarks.

- They are slow to assimilate the issue.
- They have no idea about the problems they may encounter in the industry, relationship with the staff, access to data, etc.
- Moreover, certain concepts and tools are hard to explain through a classical approach (lectures, tutorials, etc.).

On the other hand, and over the last promotions, ESPRIT's teachers noted the quality's deterioration of the final project assignments on both content and form. Indeed, the students have some difficulties linking their theoretical training with the reality of industrial environment: this is due to their ignorance of the practices within industry and generally of the world of work. Furthermore, the academic training is not sufficient to make the student capable to assimilate the industrial needs and to put them into practice in their field. As a consequence, it is very common during the evaluation panels to have:

- Poorly written reports.
- Medium oral presentations if not mediocre (communication problems). In fact, most students fail to highlight the tasks performed during the project graduation.

To circumvent these shortcomings, many engineering schools are calling upon experts and industrialists (often dearly paid) to introduce students who come mainly with their businesses, their advice and the subjects they wish to propose. But this solution partially solves the aforementioned problems because it does not guarantee complete assimilation and mastery of a clear, structured methodology to be followed by the student throughout the internship.

Consequently, all that fades on the writing of the graduation project's report, whose quality is below average on the level of the structure (methodology, plan) and information. Thus, the students have difficulties presenting their work in front of a jury and emphasizing the tasks achieved during their internship.

The transition from student status, receptor, to the engineer status, potent and operational seems problematic and strongly influences the quality and the performance of the newly graduated engineers. In the same way as the rapid evolution of technology, the requirements of this field are constantly being expanded. Therefore, it is up to the educational device to provide the student with not only a sample of what may await for him or her but above all to shape the expectations of the industry so the student can fulfill his tasks, carry out his graduation project and have an ideal start for his career.

Thus, this approach has several advantages:

- These former students are generally looking for their first job, so they are more available, unlike manufacturers who are often unavailable or their availability does not coincide with those of students (stress-related schedules).
- A newly graduated engineer can easily transmit his knowledge to those students who are often friends in life. In addition, he is motivated to make this task as he/she has a strong will to benefit students with their experience.

So, the rest of the paper is organized as follows: the section two presents the problems we worked in and a state of the art concerning our study. The section three details our approach. Then, we shall explain how we implemented our approach in the fourth section. The fifth section will be a kind of ‘learned lessons’ pulled by this approach. Finally, we shall present the conclusions of our work as well as the perspectives which open this paper.

2 Problematic and State of the Art

Several factors obstruct the information’s assimilation. Those factors are related to the environment in which the learning process takes place. Nowadays, the excessive use of Smart phones, especially during classes, worsens the situation as well as social networks (like Facebook, Twitter, etc.). Definitely these social networks are a source of distraction and delay. In fact, Philippe Meirieu says that “Only the academic knowledge that makes sense for the student could be treated sustainably. It is then tempting to promote themes and activities that may trigger the interest of the student.”

Generally, the engineering students devote the last semester of the academic curriculum for their graduation project during which the student must achieve a task within a company. For some, the result seems to be inadequate, considering the challenges that amalgamate the assets of their learning with real industrial problems.

In fact, a very theoretical training does not offer the student the means to adapt to companies that are in search for skilled and responsive technicians. In this point, appears the deficiencies of educational methods which aim to be classical in their references to the detriment of a reality more and more demanding.

According to [http://differenciation.csphares.qc.ca/?page_id=52] “The strategic education is an approach that takes into account both learning and teaching.” This approach is developed from cognitive psychology data. It is based on six principles developed by Jacques Tardif and adapted by Yolande Ouellet.

- Learning is an active and constructive process.
- Learning is essentially establishing links between previous knowledge and new knowledge.
- Learning involves both declarative knowledge (what), conditional (when and why) and procedural (how) of knowledge or expertise.
- Learning requires constant knowledge organization based on the memory representation mode, specific to each type of knowledge.
- Learning the three types of knowledge or expertise must contribute to the construction of cognitive and metacognitive strategies. These strategies are built using the steps of explicit instruction including modeling, guided practice, cooperative practice and independent practice.
- Learning is as much emotional as it is cognitive dimensions. Student motivation determines its degree of commitment, participation and persistence in their learning.

So from theory into practice the student often struggles to find his bearings. Thus, we see the lack of a necessary stage in their education which should consolidate and develop the theoretical knowledge and prepare the student for the huge propulsion in the world of work where technical and managerial qualities immediately operating are expected of him. Considering that it is the environment that selects the employee and not the opposite, the student must have a flexible profile and rapid assimilation of its role and the rules of the environment.

To put this right, the most common approach is to put students in contact with experts and experienced industrials by inviting them to present their experiences, their daily tasks they propose as internship projects, and to help build professional skills of the young students.

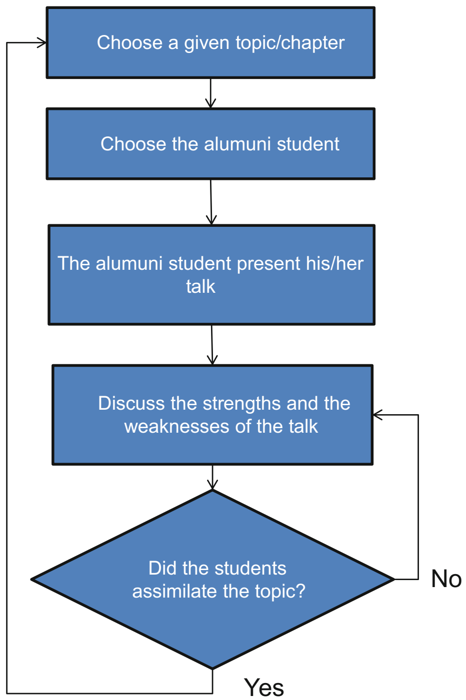
This approach illustrates the potential of the work environment in which the students have to apply their theoretical basis during their internship graduation. However, these consultations have inconveniences such as:

- Fees are often high and are out of the budget of a university institution.
- The availability of these experts is limited. It is difficult to match their time slots with students' courses scheduling, making it difficult to ensure regular interventions.
- Regarding the effectiveness of this approach, such these interventions do not guarantee the assimilation of the student to master the tasks. The speakers are practitioners and are rarely trained to transmit knowledge and teach a pedagogical method or approach.

In addition, it is well known (Perrenoud 2001) that the first goal is not to train a future industrial or in a more general case of future workers with practices and predefined methods, but to inculcate them the concept of reflection and innovation. Indeed, talking with an expert in the considered field encourage students to develop their own resolution to the problem. In our reference, an ideal field trainer should promote the clarification of expectations and learning contract; verbalize their own ways of thinking and decision-making; do not play the comedy of control, embody a standard, a superego, a model; express his doubts, fears, ambivalences, its weariness, get involved as a person, do not hide behind the role; accept differences as irreconcilable; make mistakes as opportunities for growth. This fits perfectly with our budding engineers: put reflective practice in the center of training project (Brown and Lent 1996).

3 Our Approach

Our approach consists on inviting a former student to expose a subject already chosen by the teacher. The former should have experienced this in their internship. He/she presents their talk and answers the student's questions. And finally the teacher, the former student and the students discuss the forces and the weaknesses of the talk in order to evaluate the experience and some recommendations are made for the next talk.



4 Validations

For this first experiment, we invited four former students:

4.1 The First Talk

Theme: SMED (Single Minute Exchange of Die)
Speaker: Mrs. Wala Jenzri
Highlights: Mrs. Wala Jenzri began her presentation with a summary about the SMED method which aims at reducing the changeover times. In fact, each element of the changeover is analyzed (by recording it with a camera) to see if it can be eliminated, moved, simplified, or streamlined. The essence of the SMED method is to convert as many changeover steps as possible to 'external' (performed while the equipment is running), and to simplify and streamline the remaining steps. The name Single-Minute Exchange of Dies comes from the goal of reducing changeover times to the "single" digits (i.e. less than 10 min). Finally, Mrs. Wala Jenzri explained that perfectly executed Formula 1 pit stop exemplifies principles of SMED (see Fig. 2).
Lessons learned: Mrs. Wala Jenzri gave some advices when applying this method:

- consider the 'camera effect':

– An operator may accelerate to show his superiors that he has a good performance.
– An operator intentionally slowed the rhythm so that standards are not too fast.
– The difference between the changeovers made in the morning, whole day or night (tiredness, etc.) (Fig. 1).

Fig. 1. Mrs. Wala Jenzri's talk

Fig. 2. Formula 2 pit stop

The second talk

Theme: 5S (Sort, Set, Shine, Standardize and Sustain)
Speaker: Mr. Zied Jaza
Highlights: Mr. Zied Jaza said that the 5S methodology or what was known as the Toyota Production System (TPS) is originated in Japan after World War II. This method focuses on the belief that a well-organized workplace yields a safer, more efficient, and more productive system overall. 5S is a systematic form of visual management utilizing everything from floor tape, to operations manuals, that are not just simply about cleanliness or organization, but created to maximize efficiency and profit. Instead, it is a framework that emphasizes the use of a specific mindset and tools to create efficiency and value. It involves observing, analyzing, collaborating, and searching for waste and also involves the practice of removing waste (see Fig. 4).

Fig. 3. Mr. Zied Jaza talk

Fig. 4. The 5S steps

Lessons learned: Mr. Zied Jaza asked student a simple but significant question:

- Did you know this advice: an apple a day keeps the doctor away?
  - Students' response: Yes!
- Is it an easy advice?
  - Students' response: Yes!
- And what about its regular application?
  - Students' response: It's so difficult to apply it every day!
- Mr. Zied Jaza ended his talk by saying that 5S's application in industry is exactly the same advice application! (Fig. 3).

4.2 The Third Talk

Theme: Kanban (This Japanese word means sign or card)
Speaker: Mr. Montassar Landolsi
Highlights: Mr. Montassar Landolsi began his presentation with a summary about the Kanban method which is a concept related to Just In Time (JIT) production. According to its inventor (Taiichi Ohno), Kanban is the means by which JIT is managed. Kanban is a signaling system. As its name suggests, Kanban uses cards to signal the need for an item. Other devices such as plastic markers (Kanban squares) or balls (often golf balls) can also be used to trigger the movement, production, or supply of a unit in a factory. Finally, Mr. Montassar Landolsi showed an illustration of a manufacturing managed by Kanban (see Fig. 6).

Fig. 5. Mr. Montassar Landolsi talk

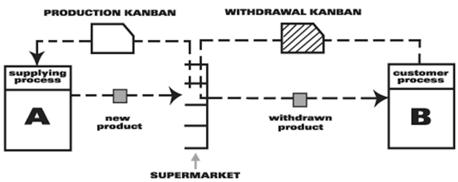


Fig. 6. The Kanban method

Lessons learned: Mr. Montassar Landolsi gave some remarks regarding the application of this method in Tunisia:

- There is a lack of rigor in the application of this method because the Tunisian mentality is different from the Japanese mentality.
- Tunisian operators do not apply formulas to calculate the number of Kanban (number of cards in circulation), they make approximations.
- Kanban cards are often forgotten, lost or ripped (Fig. 5).

4.3 The Fourth Talk

Theme: Line balancing
Speaker: Mr. Nacef Sifi
Highlights: Mr. Nacef Sifi began his presentation with a summary about the balancing approach which is the process of aligning operations within a specific production line to minimize production fluctuations and operational downtime. In addition, he highlighted that line balancing is a production strategy that involves setting an intended rate of production for required materials to be fabricated within a particular time frame. In addition, effective line balancing requires assuring that every line segment's production quota can be met within the time frame using the available production capacity. Finally, Mr. Nacef Sifi showed an illustration of a line balancing done with Excel (see Fig. 8).
Lessons learned: Mr. Nacef Sifi gave an interesting and ludic explanation (see Fig. 9) of this method: he asked student a simple but funny question:

- Did you know the story of rabbit and turtle?
  - Students' response: Yes, they made a race!
- and which won at the end?
  - Students' response: the turtle!
- Why?
  - Students' response: because the turtle kept a constant speed and the rabbit fell asleep!

Mr. Nacef Sifi ended his talk by saying that line balancing is exactly the same as this race: it is better to keep a constant output! (Fig. 7).

Fig. 7. Mr. Nacef Sifi talk

Fig. 8. The line balancing method

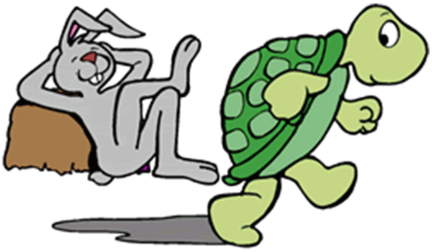


Fig. 9. The story of turtle and rabbit

5 Evaluations

To show the impact of our approach as well as estimate it, we appeal in a recording of testimonies of some students having participated in this module. We are persuaded that it is the only way to show the importance of our approach because we cannot compare seen methods, professors, and handled themes of two approaches.

- Testimony 1: It was easier for me to ask questions (even stupid questions) to a person whom I knew. He will not laugh.
- Testimony 2: I don't see any difference between these two approaches! I just want assistance for my industrial life.
- Testimony 3: It was a pleasure to see my old friends and to hear from them.
- Testimony 4: I really hope that our school ESPRIT will use this approach. It represents a good asset to the students.

Currently it is not possible to assess the impact of the experience on the quality of reports and presentations of the end of project studies because on the date of submission of this article students who have lived this experience have not yet presented their work. Also, we can only assess the results of similar or close subjects to those processed during the talk, but the majority of the students of this generation have performed projects related to energy or mechanical design. Therefore, we cannot compare unmatched subjects. To generalize this experience, we have to repeat it with two or three generations to get a measurable and interpretable history.

6 Conclusions and Perspectives

The suggested model is similar to a quality improvement initiative of engineer's performances at the acquisition of information and the reactivity of their application in industrial fields. The guarantee to have an effective generation of engineers must go with the adaptability of their mentors and their ability to integrate new methods in their methodology. In the end, it would be interesting to try this approach with other technical modules (electrical engineering, mechanical engineering, etc.)

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Participatory Development of a Bachelor's Degree Program in Industrial Engineering for Non-traditional Students

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Abstract. A bachelor's program in industrial engineering is being developed in order to meet regional industry's needs and students' interests. Collaborative aspects of the conception phase are reported in this paper. The new study program is meant to be attractive for technicians going into management, business administrators in technological companies, and high potentials with vocational training. Stakeholders were involved in the development process. In order to determine companies' requirements for such a program in industrial engineering, an online survey was conducted. The results are reported and were used, together with the other information, to put forward a curriculum that was adapted in several workshops. Competencies were grouped in three fields: engineering, business, and general competencies. Taking into account stakeholders' views lead to a program that corresponds to the target group and their experience.

Keywords: Program development · Non-traditional students · Bachelor's degree · Industrial engineering · Competencies · Participatory · Distance learning · Survey · Stakeholders

1 Introduction

In Germany the ratio of non-traditional students compared to traditional ones is rather low from an international perspective [1, 2]. The reasons are multifaceted; however, the scarcity of target-group oriented part-time study programs seems to be the most important one. Non-traditional students need them in order to master employment and academic studies at the same time. Therefore, public funding like "Upward mobility through academic training: open universities" [3] has offered an incentive for universities to develop innovative programs. Through one of these grants, Aschaffenburg University of Applied Sciences and Darmstadt University of Applied Sciences developed a bachelor's program in electrical engineering and information technology [4]. A second bachelor's program, in industrial engineering, is being developed by the

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two universities. Collaborative aspects of the conception phase are reported in this paper, c.f. [5]; in particular, the reasoning for the curriculum is given.

The new study program should be attractive for the target group, technicians going into management, business administrators in companies related to production, and high potentials with vocational training. The competencies which shall be built up need to match the typical job profile of an industrial engineer, and fit the qualification and job experience of the target group. It should be noted that this profile depends on the industry, where the job is embedded, and might differ in different countries.

Therefore, the development process is affected by stakeholders shown in Fig. 1. The target group is pivotal in the conception phase. It is well known that these students are very much intrinsically motivated [6, 7]. The number of semesters is a compromise of work load in ECTS credit points and duration of the program. Since these students have to pay tuition for continuing education, contrary to other students in Germany, they will have higher expectations. Preparatory courses and assistance will be needed for people whose formal education was long ago. Students are linked to employers who can foster or inhibit their wish for development. A general scarcity of engineers might help to look for new ways to find workforce.

Typical skill profiles of industrial engineers are researched and compiled by the Syndicate of German Industrial Engineers [8]. They recommend a general framework for programs in this field [9], which is considered by accreditation organizations. Accreditation is the quality assurance for a program within the Bologna process [10], and required by the Bavarian State Ministry of Education and Studies, which gives permission to a new program. Non-traditional students have been focused since 2009; different educational paths were opened for freedom of choice and social justice.

Competitors are other universities with academic programs for non-traditional students. During the development process the market needs to be analyzed with respect to relevant study programs and tuition fees, c.f. [11].

Internal stakeholders are groups or committees within the university. The board needs to agree to a new program in line with the strategy of the university. Exam regulations and modules will be passed by the senate after discussions in the faculty.

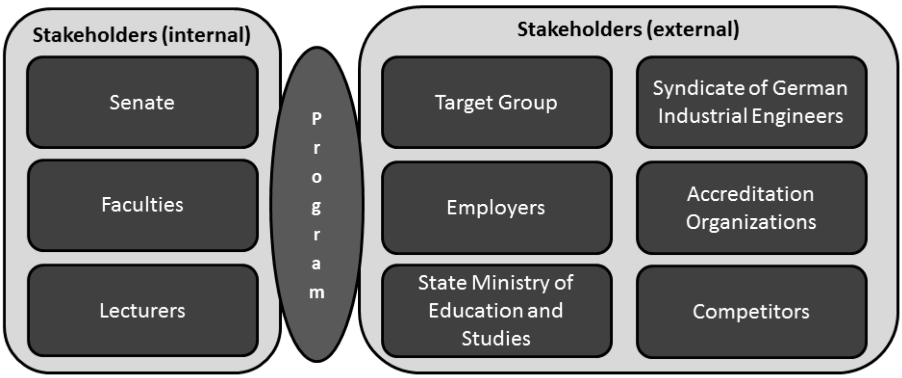

Fig. 1. Stakeholders of the development of degree programs

Quality aspects will be considered in the decision as well as the potential for innovation. For lecturers, a study programs for non-traditional students is didactically challenging because of new requirements: time constraints due to employment of the target group, hands-on experience, and possibly fewer years of formal education. Adequate learning material, activation and quizzes are important to help distant learners to learn effectively [12]. On the other hand, teaching this group can be rewarding since they are more committed, and often more mature being older.

2 Approach

Figure 2 illustrates the approach chosen for the participatory development process of the bachelor's program in industrial engineering along the line of Biggs' idea of competency orientation in curriculum design [13]. In this approach as many stakeholders shown in Fig. 1 as possible and reasonable were involved. For this purpose our approach is steered by an assessment of needs for educational offerings and by a skill-oriented development of academic programs [14].

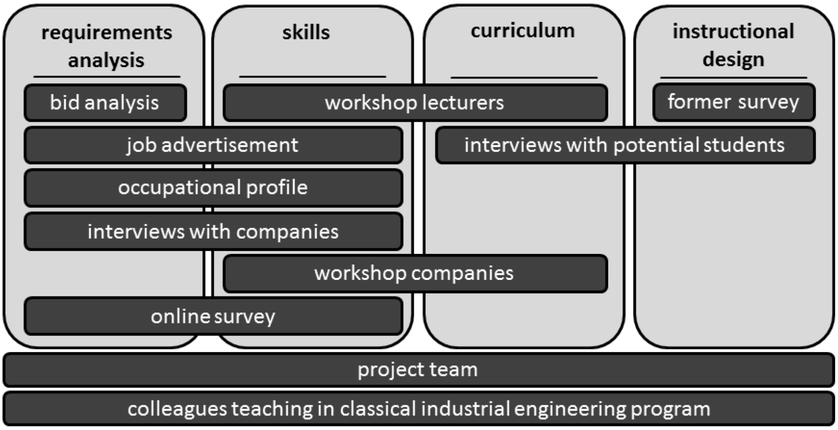

Fig. 2. Methodological approach: phases of development horizontally in time and corresponding employed methods [14]

In the beginning of the requirement analysis a bid analysis was conducted. Ten bachelor's study programs in industrial engineering for non-traditional students at German universities were analyzed with respect to duration, curricula, and tuition fee. In order to determine further requirements and skills, current job advertisements from regional companies were evaluated. A study by the Syndicate of German Industrial Engineers [8] was taken into account, and several interviews with companies' representatives were used for qualitative input. An online survey was conceived to find out systematically what companies expect of a graduate. At the same time, this survey was a means to get into contact with relevant enterprises for marketing, and to identify current trends in the labor market. Representatives of regional and international companies were asked questions in the following categories:

- Desired competencies and skills in graduates of industrial engineering.
- Demand for this bachelor's program and certificates derived from it.
- Companies' support for employees who study alongside working.
- Opportunities and threats for the company linked to such a program.
- Current involvement in continuing education activities.
- Basic data of company.

The questionnaire was created and deployed with the help of Questor Pro 1.4. The access to the survey was sent via e-mail to selected companies' representatives and handed out at a conference. In the end 31 answers from companies were available. The evaluation was used as input for the conception of the new study program. As shown in Fig. 2 workshops for potential lecturers and companies' representatives were organized to discuss skills needed for industrial engineers. By means of group processes, the initial version for a curriculum was improved in iterations. Nine representatives of companies participated in the workshop, of which three also covered the role "studying employee", and five members of the project team.

We attempted to interview potential students in a structured way for the development of the curriculum. However, in spite of putting in quite some effort, the interviews could not be organized as planned. The identified persons were too busy, or just did not prioritize the interview. Some complementary information was gathered by interviewing students of another engineering program in continuing education, and including the results of a former survey concerning instructional design [4].

In the development process of the new study program, the project team discussed the status of the curriculum regularly; some meetings were arranged with colleagues teaching a classical industrial engineering program.

3 Results

3.1 Requirements Analysis

The requirements analysis reveals the competitive market situation of private and public institutions offering bachelor's degree programs. The mean value of the eight tuition programs is about 1940 €. The duration of the programs varies between six and twelve semesters.

The analysis of required competencies yields four categories: A graduate of a bachelor's degree in industrial engineering should be a generalist with a solid background in engineering and business, and dispose of general competencies including soft and intercultural skills. Fields of knowledge are technology, management, and methods. Working alongside in a company adds practical relevance to learning and allows for application of the theory.

In the online survey, companies' representatives mostly agreed (16 out of 31) that their company would use the new bachelor's program for interested employees, whereas eight did not. Ten respondents identify employees in their company for studying the program, eight do not, and ten are uncertain. Nine companies – about one third of the answers – are interested in using just specific modules of the new bachelor's program. The others are not interested or did not answer the question.

In the answers, the majority of companies offer support to employees who study: 21 firms will "take share in tuition fees". Five firms would even "take over tuition fees completely". 19 firms would grant "leave for courses on campus". 13 companies plan to help their students with "non-material support". Twelve firms offer a "reduction of working hours without wage adjustment", seven a "reduction with wage adjustment". "Support based on guidance" was held out in prospect seven times. Only one firm marked "no support". Most companies (25) already support studies of their employees; only three do not. Half of the companies use cooperations with universities or other providers for continuing education. Further-more, most companies do have a positive attitude towards continuing education, and do not see it as a risk. In the contrary, they regard it as an opportunity for the company and as an element for enhancing the employee's commitment. The answers to the open questions suggest that companies are aware of possible problems, which may, e.g., arise if they support someone out of a team. The person might be overburdened by studying and working, others might be jealous. Overall, companies expect more positive effects.

3.2 Skills and Competencies

All channels described in Sect. 2 were used to identify the skills and competencies needed by an industrial engineer, and the results were merged.

Companies indicate in their answers that a solid, broad foundation in business and engineering is most important at the workplace. Runners up are methods and life-long-learning skills. This structure was taken as a starting point for the workshops. The findings of the online survey were in general supported by the discussions on the occupational profile of an industrial engineer. The characteristic of the program is the ability of graduates to work at the interface of business and engineering. A number of desired interdisciplinary skills and competencies reflect this feature; e.g., project management, quality management, innovation management, intercultural communication, negotiation, mastering the English language, and internet technologies.

The competencies in the economic sciences were quickly agreed upon. In the field of engineering, the choice was more difficult. The guiding principle of providing graduates with a "broad" engineering background, and the regional industrial structure, lead to a cluster of competencies from electrical and mechanical engineering.

3.3 Curriculum

The curriculum was iteratively discussed with stakeholders. In particular, colleagues teaching the full-time industrial engineering program at Aschaffenburg University of

Applied Science were involved at this stage. These collaborative aspects of the development process contributed to the inclusion of the stakeholders' views into the curriculum. The process converged without any unbridgeable controversies. The results were compared with the recommendations of the Association of German Engineers for designing a degree program in engineering [5], and the general reference frame for industrial engineering published by the Syndicate of German Industrial Engineers [9].

The curriculum that evolved out of this process is given in Fig. 3. Principles of engineering and natural sciences are placed in the first semesters. In parallel, basics of the economic sciences are taught. Modules aiming at core competencies are placed in later semesters. Interdisciplinary modules create a connection between aspects in engineering and business, and convey methods. Students may choose from several electives in all three fields of competency. Furthermore, modules can be chosen from a catalogue of the Bavarian Virtual University, a network of universities in Bavaria. Since non-traditional students with work experience will often have competencies of the curriculum at command, a process for recognition is planned.

Using synergies with an existing engineering program for non-traditional students helps to meet cost requirements. Therefore, the size of the modules needs to be compatible. Dual use is possible for some modules, e.g., in the realm of methods, which are prone to be electives for electrical engineers. Moreover, students of both programs will benefit from the diversity of participants.

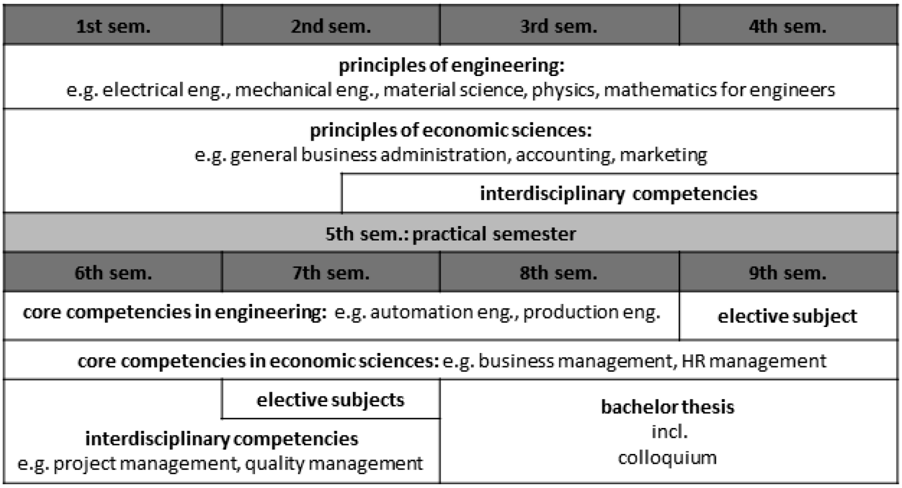

Fig. 3. Proposed curriculum for non-traditional students in industrial engineering

3.4 Instructional Design

Based on our experiences with an electrical engineering program, the instructional design was aligned to the lessons learned since 2013. Regular attendance at university has to be diluted to make it possible to combine work and study. Additionally, learning material must be available independently of location and time so that students can use it flexibly. For efficiency, these students need orientation and well-structured material. Problems and formative evaluation should allow them to judge their learning progress [4]. The instructional design chosen is given in Fig. 4: A blended-learning concept was designed. A semester starts with two days of attendance (Friday and Saturday) at the university premises followed by some four weeks of self-study. After another cycle of attendance and self-study the courses end with a competency-oriented exam. Thus, students have to juggle just two modules at a time. Thereafter, another block with the same structure follows. Once a year, a three-day attendance phase is offered for intensified study in a lab.

During the self-study phases students' learning activities are supported by text books and e-learning content. To evaluate their learning progress students should have the option to use quizzes and to work on selected tasks. For all courses the learning material is provided on the learning platform Moodle, which is also used for communication. The concept follows the principles of self-regulated and collaborative learning as well as target-group orientation.

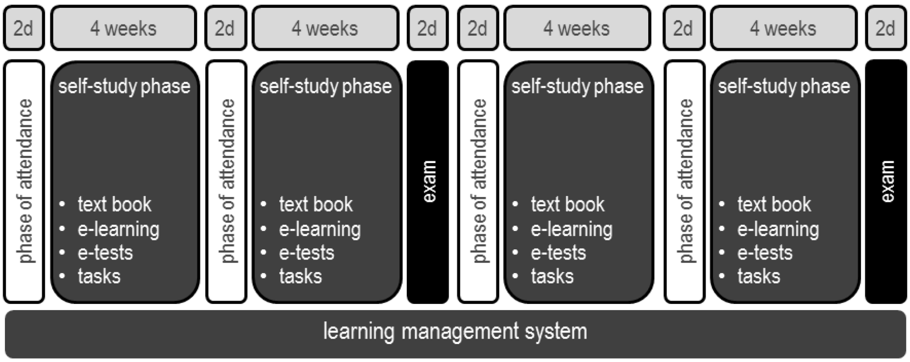

Fig. 4. Instructional design of study programs for non-traditional students at Aschaffenburg University of Applied Sciences. 2d stands for two days.

4 Conclusion

Reflecting the method of the approach, one can see that a number of survey instruments were used in each phase of the development. Most of the stakeholders were able to participate in the development process of the bachelor's degree program in industrial engineering. Nonetheless this approach suffers from weaknesses: It seems to be difficult to involve all stakeholders. For example, potential students could not be found for structured interviews. The absolute figure of companies that answered the questionnaire was satisfying, albeit the return rate was low.

Most likely, the answers have some bias towards companies interested in continuing education. On the other hand, this is helpful to get in contact with employees that might become students. Thanks to the here-proposed approach a bachelor's degree program in industrial engineering was developed that fits the regional economic structure, and is in line with the general reference frame published by the Syndicate of German Industrial Engineers. Even if this process takes more time in the initial phases, we are confident that the discussion process pays off in the long run and will lead to higher acceptance of the program within the university and on the market.

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The Impact of Academic Staff Development on the University Internationalization

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Abstract. This article is focused on development of the academic staff competencies that contribute to the university internationalization. A list of the competencies is defined, including mastering English for professional purposes in order to deliver academic courses and to conduct R&D in English; ability to develop educational programs in coherence with international standards; ability to create a bilingual intercultural academic environment; ability to adopt world best practices in teaching and investigations, etc. The complex of academic staff training programs delivered at National Research Tomsk Polytechnic University and aimed at the university internationalization is presented. The focus is made on English language proficiency development.

Keywords: Higher education internationalization · Competency-based academic staff development · Global competitiveness in higher education

1 Introduction

Development of Russian higher education seeking international recognition and looking toward the global competiveness influences engagement of academic staff in internationalization processes. Internationalization requires integration of international, intercultural, and global dimension into the purpose, functions, and delivery of higher education [1]. The main modes of the university internationalization are:

- ***Academic affairs:*** producing globally competent graduates; students and academic staff international mobility; delivery of joint educational programs; delivery of educational courses through the medium of English, etc.;
- ***R&D:*** theory based research and investigations in collaboration with other academic institutions; articles in international scientific journals; participation in international conferences, competitions, programs and grants; transnational research projects, etc.;
- ***Management:*** participation in cross-border consortiums; strategic partnership with international organizations; the achievement of world class status, etc.

Tomsk Polytechnic University (TPU), one of the leading Russian universities, is influenced by internationalization processes taking place in Russian higher education as it is put in the goal and preamble to 5-100 Russian Academic Excellence Project—to maximize the competitive position of a group of leading Russian universities in the global research and education market [2].

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Namely, as Project 5-100 participant TPU has set its priorities in further rapid advancement of its research schools and quality of its educational services which is to result in increase of number of articles in Web of Science and Scopus databases; percentage of international professors, teachers and researchers among research and teaching staff; percentage of international students enrolled in main educational programs; and subsequently in enlarging the number of educational programs delivered in English as well as increase in income from international programs and grants in total amount of income-generating activities [3].

2 Academic Staff Development at Tomsk Polytechnic University: Internationalization Focus

Transformation of Russian universities into internationally competitive academic institutions requires sufficiently high level of academic staff competencies development. There is a unique continuing professional development (CPD) system created in TPU [4] which is aimed at the development of academic staff key competencies including the competencies contributing to the university internationalization, among them are the abilities to:

- perform professional activities through the medium of English;
- design educational programs (courses) in accordance with national and international educational standards as well as in compliance with the criteria introduced by the Association for Engineering Education of Russia (AEER) and international accreditation agencies;
- deliver educational programs (courses) implementing the world best practices of the leading universities;
- collaborate with international universities in design and delivery of joint educational programs.

The system of training programs offered for TPU staff consists of more than 40 CPD programs. The programs are outcomes-based and incorporate best practices of engineering education. About 30% of academic staff takes part in the CPD programs annually. Methodological support, modern educational technologies, and teaching aids make educational process more efficient. The educational technologies include but are not limited to blended learning, problem-based learning, and collaborative learning.

One of the key competencies influencing on the university internationalization is English language proficiency. The system of foreign language training for TPU staff is described below.

3 Language Training

3.1 Language Training Development

Ability to perform professional activities through the medium of English has become one of the key competences for TPU staff. The increased number of international students and curriculum modernization pointed out the challenge for academic staff, in terms of maintaining and improving their intercultural competency and language skills.

Analyzing the university inner and outer environment the following conclusions were made.

Situation Before:

- content teachers deliver subjects in tandems with English for specific purposes (ESP) teachers or in native language;
- ESP teachers deliver English language classes for students in engineering and technical fields (ESP) to learn terminology and master translation skills.

Situation Now:

- content teachers train international students via English;
- ESP teachers deliver ESP with measurable outcomes valid for professional performance (research papers, grant applications, etc.).

Existing Gap:

- content teachers need to master English language proficiency and tools for pedagogical design;
- ESP teachers need content area knowledge.

This challenge is embodied in the system of professional enhancement programs in English and German as foreign language at the university which has been developed at TPU since 1990s. Currently, the system incorporates 21 program with core module based programs aimed at foreign language proficiency enhancement from beginners to advanced level and a number of short term programs which target specific focus areas of professional fields for TPU research and teaching staff.

The target audience for training programs has evolved since 2009 until present from research and teaching staff adding new categories of university employees—senior and middle managers, professional services staff whose professional duties according to TPU new goals of development now include hosting international delegations, front desk service for international faculty and students, document flow in English, etc.

The system of language training programs at the present stage of its development offers three main trajectories for TPU research and teaching staff in its professional enhancement:

– Training for enhancement of foreign language proficiency.
– Design of educational courses to be delivered through the medium of English.
– Mastering academic and scientific writing skills.

According to professional enhancement pathways the examples of results are the following:

– Training for enhancement of foreign language proficiency—certificate of foreign language proficiency.
– Design of educational courses to be delivered through the medium of English—educational course developed in compliance with Russian federal educational standards and international standards of engineering education, e.g. CDIO, EUR-ACE Framework Standards and Guidelines, IEA Graduate Attributes and Professional Competencies, etc.

– Mastering academic and scientific writing skills—research paper submitted and accepted for publication in international scientific journals indexed in Web of Science or Scopus databases.

3.2 Principles and Structure of Language Training

The system of foreign language training for TPU staff is based on groups of certain principles:

- didactic (among them andragogy and pedagogy of learning and acquisition, methods of foreign language training);
- methodological (active technologies of learning and acquisition, blended and online learning);
- organizational (sequential algorithm of stated achievements; programs sequence logistics; large volume of independent studies);
- programs internationalization;
- profession specific content focus [5].

The necessity for professional competences development for TPU research and teaching staff allows breaking training process into the pathways to develop corresponding skills in:

– Language proficiency enhancement (English and German).
– Delivering through the Medium of English.
– English and German for research.

The breakdown of staff categories-programs participants in the above mentioned pathways of training is presented in Table 1.

3.3 Validation of Training Results

Validation of training results is performed in different ways.

For training pathway Language proficiency enhancement (English and German) the validation is performed via independent testing procedures which enable TPU staff to take certificate format exams[1] in English and German at TPU. By 2015 94.4% of TPU staff took the certificate format exams at TPU and confirmed the level of training for language proficiency stated as Module based programs learning outcomes.

For training pathway Delivering through the Medium of English the learning outcome and validation of studies result is the number of educational courses developed and introduced into teaching practice at TPU. Namely, in 2016 some of the e-learning courses developed within the programs were acknowledged as the best ones in TPU practices.

[1] TPU certificate exams are designed in compliance with Cambridge Exam certificates system that allows to evaluate the language proficiency from Basic and Proficient User.

Table 1. Breakdown of staff categories for language training programs

Training pathway	Programs	Average number of qualified graduates per semester, in persons	Average percentage of research and teaching staff in total number of program participants per semester (%)
Language proficiency enhancement (English and German)	Module based programs in English as a foreign language	70–80	83
	Module based programs in German as a foreign language	10–12	80
Delivering through the medium of English	Education technologies in ESP for higher education	10–12	100
	Educational course design in English	10–12	100
	Forming didactic competence in Science and Education	10–12	57
	Delivering through the medium of English	24	100
	Blended learning	16	100
English for research	English for Science and Engineering	10–12	100
	Writing for publication	14	100

Comment: The last column represents the percentage of research and teaching staff in total number of programs' participants in autumn semester 2015/2016 and serves to illustrate the overall tendency in research and teaching staff participating in programs according to the training pathway stated in column 1. Such percentage of research and teaching staff participation is common for the last three years of the programs realization

For training pathway English for research the verification of learning results is the follow-up—stretched in time monitoring of research staff success in international grants applications, participation in the work of international laboratories based on TPU premises.

3.4 Results

Statistical data demonstrates the increase in number of research and teaching staff taking part and successfully graduating from language training courses since 2013 (Table 2).

Table 2. Number of qualified graduates in all training courses, in persons

Year	2013	2014	2015	Spring 2016
Number of qualified graduates, in persons	115	192	396	190

Comment: Number of qualified graduates in all training courses is calculated based on number of certificates issued. Since 2015 the number of programs increased as well as number of graduates, respectively

Since 2012 joint educational programs of TPU and University of Southampton (UoS), UK (81 QS ranking 2015, university—member of the Russell Group) have been offered. The number of TPU-UoS programs qualified graduates and achieved results are presented in Table 3.

Table 3. Number of qualified graduates in TPU-UoS programs (in persons) and results

Programs	Number of qualified graduates 2012–2015, in persons	Results
Delivering through the medium of English	72	More than 100 courses developed and implemented
Blended learning	32	
Writing for publication	31	More than 30 research papers prepared and submitted to peer-reviewed science journals with high impact factor
Senior Managers	12	More than 10 projects in university change management prepared and implemented
Total	148	

4 Conclusions

The internationalization of higher education is the strategic goal of many universities around the world. This process requires the involvement of academic staff in continuous professional development with focus on the international activities. One of the key competencies in this context is English proficiency. For the development of these competencies a correspondent academic environment should be created, including educational programs, assessment methods, etc. The case of Tomsk polytechnic university demonstrates an effective academic staff development structure that has contributed to the university internationalization.

As a result of systematic measures taken for the university development and internationalization, part of which is TPU staff training in foreign languages, TPU is the leading university in the group of elite Russian universities within 5-100 Russian Academic Excellence Project in:

- Percentage of international graduate and postgraduate students enrolled in main educational programs—more than 23%.
- Percentage of income from non-budgetary sources in the total revenue structure of the university—over 33% [6].

These are the best results among all national research universities—participants of 5-100 Russian Academic Excellence Project by 2015.

TPU experience in development of the academic staff competencies contributing to the university internationalization, especially in language proficiency training, is among the university best practices, interest to which is sustained through a number of all-Russian scientific events held on TPU premises. The offered by TPU system of language training for the university staff can be easily adapted and implemented in other universities that educate their students in English as foreign language and make the international recognition in education and research as one of their main development goals.

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