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Fourth Issue of the Journal of Problem Based Learning in Higher Education

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INTRODUCTION TO THE FOURTH ISSUE

We are pleased to introduce the fourth issue of the Journal of Problem Based Learning in Higher Education. Current issue is composed of five research papers and two PBL cases. These address different aspects of PBL in higher education as and represent an international experiences and knowledge with contributions from Brazil, Denmark, Germany and Morocco. The first three papers and the two cases touch upon the role of the teacher in facilitating problem based learning processes. These papers address the complex questions of how teachers can actually implement and teach PBL to students. The fourth paper reports on students' attitudes towards different types of exams (e.g. individual exams and group exams) in two engineering programs at Aalborg University. The fifth paper compares three different learning designs in an introductory computer science course on programming. The current issue explores a diverse set of aspects related to research in Problem Based Learning: teachers and supervisors roles, implementation of PBL curricular, assessment formats supporting PBL and new advances in combining technology and PBL.

Papers:

- Derfoufi, Sanae, Benmoussa, Adnane, El Harti, Jaouad, Ramli, Youssef, Taoufik, Jamal, and Chaouir, Souad. "Impact of Active Teaching Methods Implemented on Therapeutic Chemistry Module: Performance and Impressions of First-Year Pharmacy Students." *Journal of Problem Based Learning in Higher Education* 3, no. 2. doi:10.5278/ojs.jpblhe.v0i0.1207.
- Hernandez, Carola, Ravn, Ole, and Valero, Paola. "The Aalborg University PO-PBL Model from a Socio-Cultural Learning Perspective." *Journal of Problem Based Learning in Higher Education* 3, no. 2. doi:10.5278/ojs.jpblhe.v0i0.1206.
- Mühlfelder, Manfred, Konermann, Tobias, and Borchard, Linda-Marie. "Design, Implementation, and Evaluation of a Tutor Training for Problem Based Learning in Undergraduate Psychology Courses." *Journal of Problem Based Learning in Higher Education* 3, no. 2. doi:10.5278/ojs.jpblhe.v0i0.1195.
- Dahl, Bettina and Kolmos, Anette. "Students' attitudes towards group based project exams in two engineering programmes." *Journal of Problem Based Learning in Higher Education* 3, no. 2. http://dx.doi.org/10.5278/ojs.jpblhe.v0i0.1108

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- Lykke, Marianne, Coto, Mayela, Jantzen, Christian, Mora, Sonia, Vandel, Niels. "Motivating students through positive learning experiences." *Journal of Problem Based Learning in Higher Education* 3, no. 2. http://dx.doi.org/10.5278/ojs.jpblhe.v0i0.1130

Cases:

- Amaral, Joao Alberto Arantes do, and Gonçalves, Paulo. "The Use of System Thinking Concepts in Order to Assure Continuous Improvement of Project Based Learning Courses." *Journal of Problem Based Learning in Higher Education* 3, no. 2. doi:10.5278/ojs.jpblhe.v0i0.1174.
- Amaral, Joao Alberto Arantes do, Gonçalves, Paulo, and Hess, Aurélio. "Creating a Project-Based Learning Environment to Improve Project Management Skills of Graduate Students." *Journal of Problem Based Learning in Higher Education* 3, no. 2. doi:10.5278/ojs.jpblhe.v0i0.1178.

Papers

In the first paper, Sanae Derfoufi, Adnane Benmoussa, Jaouad El Harti, Youssef Ramli, Jamal Taoufik and Souad Chaouir report a study from Casablanca Medical and Pharmaceutical College in Morocco. In their paper "Impact of active teaching methods implemented on therapeutic chemistry module: Performance and impressions of First-year pharmacy students", they have found that the Case Method, originally described by Barrows (1986), could facilitate students learning. However, the authors also note that professors need to acquire complex teaching skills to integrate the Case Method into curriculum. To ensure that teachers acquire such complex teaching skills the authors suggest making pedagogical workshops aiming at this. Thus the paper addresses a central concern in PBL research – namely the role of the instructor/teacher in PBL environments. A structured design for scaffolding student's participation, reflection, critical thinking and dialogical skills is presented and evaluated through pre and post-tests. Among other things, the results show interesting student views on: the difference between traditional lectures and the Case Method and the positive experience of working together in teams to solve a problem.

In the second paper, titled "The Aalborg University PO-PBL Model from a Socio-cultural Learning Perspective" by Carola Hernandez, Ole Ravn and Paola Valero, the authors present and discuss some of the principles of Project Organized – Problem Based Learning (PO-PBL) at Aalborg University particularly based in studies from the Faculty of Science and Engineering. The authors develop their argumentation about PO-PBL by revisiting some of the basic principles of PBL from a sociocultural perspective. As pointed out by the authors, it is important that research on PBL focus on how students are learning together in their groups, rather than focusing on individual learning processes and outcomes in PBL settings. In PBL research the group, they argue, should be the unit of analysis. In addition, the authors argue that learning should be viewed as a process of participation in scientific communities with fellow students and teachers/supervisors, and as such also an issue of identity and becoming a certain type of practitioner. Thus, the paper also addresses the role of teachers in PBL universities, e.g. what type of questions should teachers ask to promote a scientific discourse?

By revisiting some of the core principles of P0-PBL the authors manage to highlight the positive relation between the competences gained at a PBL university compared to traditional educational institutions. Furthermore, it is clear that these competences are increasingly needed to become 'an engineer in the real world' in the 21st century. In the final discussion, Hernandez, Ravn and Valero suggest that more research is required on how groups function and how teachers can engage with the students in a mutual learning partnership.

The third paper titled "Design, implementation, and evaluation of a tutor training for problem based learning in undergraduate psychology courses" by Manfred Mühlfelder, Tobias Konermann and Linda-Marie Borchard presents and discusses how student tutors can introduce PBL to new students at the university. Based in a "Train the Tutor" (TnT) program and Hungs (2006) 3C3R model the authors outline a pedagogical model for introducing PBL at university level. By making more experienced students introduce PBL to new students several learning goals were achieved: the tutors had to develop metacognitive, facilitator and tutor skills in order to teach new the students. The study further shows that intensive training of PBL tutors ("Train the Tutor") promotes development of critical metacognitive skills and behavioural skills compared to other instructional methods, such as self-study.

In the fourth paper by Bettina Dahl and Anette Kolmos, the authors present a study of students' attitudes towards individual and group-based exams from two educational programmes "Architecture and Design" (A&D) and "Software Engineering" (SE) at Aalborg University. A&D and SE are both engineering programs; however, curricula and intended learning outcomes differ, which might also influence students' attitudes towards exams. Dahl and Kolmos highlight the culture of each program as a crucial frame influencing students' attitudes towards exam formats. In addition, the authors show that around half of the student group across both programs indicate that the group exam format influence their preparation for the exam. In spite of the different attitudes towards exams between the two students groups, a majority of the students express that group exams provides a better opportunity to show project and process related competences during exams. In conclusion, the authors argue that 'there is *not* a "one size fits all" exam when assessing PBL projects", however, it requires careful management from the programs and study boards to make sure that exams encompass assessment of the individual and group, the curricular as well as the PBL related competences. Finally, Dahl and Kolmos hypothesise that "Educational change might be very difficult if all curriculum elements always have to be aligned", however, as pointed out by the authors a misaligned curriculum might foster difficulties in predicting what students learn or how they will act upon these more uncertain circumstances.

Fifth paper titled "Motivating students through positive learning experiences: A comparison of three learning designs for computer programming courses" by Marianne Lykke, Mayela Coto, Christian Jantzen, Sonia Mora, Niels Vandel compare three different learning designs in terms of their motivational affordances for students learning to program. The authors describe an experimental, controlled comparison of three learning designs from an introductory computer programming course in Costa Rica: '1. A traditional teacher-led course; 2. A problem based learning (PBL) course; and 3. A PBL course combined with the use of LEGO Mindstorms Robots.' The purpose of the study was to explore how these learning designs could motivate students and eventually decrease dropout rates among computer programming students, which is recognised as an internationally well-known problem. Methodologically the study applies three different techniques: surveys, walk-alongs and non-participant observations. Initially the authors believed that a combined learning design utilizing PBL and LEGO Mindstorm robots would motivate students most. However, the results show that the pure PBL learning design was more motivating for the students. Further that the students value a closely present supervisor to guide and direct the group. In addition, the authors present a very interesting survey method to probe and understand students' experiences – a method which could perhaps be of wider interest in relation to understanding PBL in Higher Education.

Cases

Joao Alberto Arantes do Amaral and Paulo Gonçalves present a case exploring relations between PBL and System Dynamics Theory in a MBA course in Brazil. The authors present a design developed over a period of 12 years for integrating PBL into a traditional curriculum with a main emphasis on building relationships with external partners – what the authors refer to as Community Partners. According to the authors it is possible to improve teachers and 'students' enthusiasm and commitment by improving the quality of educational resources and the teaching methodology'. Due to the historical trajectory of this project it is possible to see how the numbers of projects and community partners have increased over time.

In "Creating a Project-Based Learning Environment to Improve Project Management Skills of Graduate Students" Joao Alberto Arantes do Amaral, Paulo Gonçalves and Aurélio Hess introduce a case from the MBA degree in Project Management at the University of São Paulo, Brazil. This case equally shows how universities and NGO's can work together to solve problems in the local community. As resonating well with the existing PBL literature, the authors also found that students became motivated by the intense collaboration between theory and practice.

We wish to thank all authors for their contribution and a very special thanks to all the reviewers who have provided excellent comments and suggestions for improvements to the individual papers.

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ABOUT JPBLHE

The Journal of Problem Based Learning in Higher Education is an Open Access journal meaning that all papers published are freely available to researchers and the general public. There is no subscription fee, no publication fee and no pay-wall. We believe this is particularly important because Problem Based Learning as a pedagogical philosophy and educational method is attracting attention in parts of the world where economic difficulties can hinder access to recent research. Although peer-reviewing, authoring and editorial work is considered part of academic practice running a journal is not free of costs. We would therefore also like to thank the Aalborg University board of Executive Directors for providing some basic funding for running the journal; Aalborg University Library for hosting and supporting the JPBLHE website and submission system (which is built on the open source system Open Journal Systems (http://pkp.sfu.ca/?q=ojs)) and Aalborg University press for being the official publisher of the journal.

Editorial team and the Editorial board:

BACKGROUND OF THE JOURNAL

The idea and foundation for creating JPBLHE emerged as an outcome of the establishment of the PBL academy at Aalborg University (www.pbl.aau.dk). The PBL Academy at Aalborg University (AAU) is a-cross faculty initiative to ensure the continuous development of the Aalborg University Model of Problem Based Learning (PBL). However, to ensure a vibrant development of PBL it is of the utmost importance to keep up with international research, and to contribute to ongoing development of PBL as an area of research. Therefore, one of the goals of the academy was to initiate an international, interdisciplinary open access journal with a specific focus on PBL in Higher Education. The journal has thus emerged as a collaboration between a number of research environments in Aalborg University e.g. "The UNESCO chair in Problem Based Learning", "e-Learning Lab – center for user driven innovation, learning and design", and "the Department of Learning and Philosophy" to name a few. Although the journal has grounding in these environments the ambition is to create and sustain a truly international and interdisciplinary journal. In relation to this, it is also important to emphasise that the journal does not foreground or favour particular approaches or PBL models. Rather, the aim is to explore, discuss and render visible the many different ways in which PBL is practiced within Higher Education. Therefore, we have aimed to establish a broad, internationally oriented Editorial Board composed of prominent and esteemed researchers within PBL; and we hope to be able to continuously expand the Editorial Board, the Editorial team, and the number of reviewers and authors. With this first issue, we feel that we have managed to attract both an international and interdisciplinary set of papers and authors, and we hope the readers will find the discussions and findings as interesting as we do.

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Impact of Active Teaching Methods Implemented on Therapeutic Chemistry Module: Performance and Impressions of First-year Pharmacy Students

Sanae Derfoufi, Adnane Benmoussa, Jaouad El Harti, Youssef Ramli, Jamal Taoufik, Souad Chaouir *

ABSTRACT

This study investigates the positive impact of the Case Method implemented during a 4-hours tutorial in "therapeutic chemistry module". We view the Case Method as one particular approach within the broader spectrum of problem based or inquiry based learning approaches. Sixty students were included in data analysis. A pre-test and post-test were conducted along with the tutorial class. A standard anonymous questionnaire was used to survey students' impressions about lectures. Results show that students obtain higher scores for the post-test compared with the pre-test. We could state that there is clearly a need to extend this experience even for other modules. However, it would seem essential to admit that professors, especially in our context, need to acquire complex teaching competences. The new reform of pharmaceutical studies, planned for the next academic year 2015-2016, would represent an excellent opportunity to plan regular workshops and training sessions for professors in active pedagogy field.

Keywords: Problem based learning, tutor skills, metacognitive skills, tutor training, tutor effectiveness

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INTRODUCTION

Casablanca Medical and Pharmaceutical College, belonging to University Hassan II Casablanca, is the second oldest Medical and Pharmaceutical College of Morocco, admitting nearly 60 students annually in the pharmaceutical curriculum. The pharmacy programme offered in Casablanca Medical and Pharmaceutical College as well as the other Moroccan public college in Rabat, belongs to regulated access universities of the Ministry of Higher Education ("Official Bulletin n° 5222 of June 17th, 2004,"). It is a 3-year semester-based programme followed by a 1-year trimester-based practical training that leads to a doctoral degree in pharmacy. The pharmacy section was introduced in Casablanca Medical and Pharmaceutical College in 2010 with a class size of 65 in the academic year 2012-2013. To integrate the pharmacy curriculum in Morocco, student must have a General University Studies Diploma, following a 2-year semester-based programme in the Biology and Geology department in Faculty of Sciences (Article 4, Decree No. 2-85-144 of August 5, 1987). Then, students have to pass an entrance examination ("Official Bulletin n°3901 of August 5th, 1987,page:233,"). The total number of years studied after the High-School Certificate in the Moroccan pharmacy curriculum is 6 years.

Four educational forms are preconized by the Moroccan Decree: lectures, tutorials, practicals and coaching Clerkship (Article 4, Decree No 2-98-548 of Febriary 15th, 1999). According to that Decree, professors should update the content and teaching methods whenever necessary and with the assistance of professional backgrounds. Nevertheless, only traditional teaching forms have been used up to now in “therapeutic chemistry module”. The traditional teaching forms of the “therapeutic chemistry module” include 56 hours of lectures, 12 hours of tutorials, and 16 hours of practicals (see Table 1).

Table 1 Number of chapters, hours and teaching forms of the three sections of ‘therapeutic chemistry module’

Sections	Number of chapters	Number of hours allocated to lecture	Number of hours allocated to tutorial	Number of hours allocated to practicals
Chemical nomenclature	3	8	4	16
Organic chemistry	3	24	8	
Medicines’ specificities	4	24	0	

In this paper, we focus on the teaching forms of the module-3 of ‘Common Technical Document’ (CTD). The CTD chapter is taught in a mix of deductive teaching, examples, and inquiry-based teaching. Deductive teaching is applied for the contents headings and hierarchy of module-3 of CTD (see Table 1). Examples are usually used to illustrate deductive information during lectures. These examples concern some real documents of the CTD such as European monograph, analysis certificate, Safety Data Sheet, stability results, etc. The inquiry-based teaching is used, for example, to teach the various sources and types of impurities in pharmaceutical products. So, instead of beginning with enumerating sources and types of impurities and then getting some examples for application, students are presented with a challenge (question about what could be the various sources of impurity in pharmaceutical products?) and they thought and grappled to give the correct answer. To accomplish the desired learning in the process, we give them chemical structures of both pharmaceutical product and many impurities and ask them the type (organic or inorganic) and the source of these impurities such as degradation, manufacturing processes, Synthetic intermediates, etc. (Pilaniya et al., 2010).

Despite efforts made, we have noticed that students could not remember the contents headings and the hierarchy of CTD items. Moreover, many students could not understand how the real CTD information looks like. For example, they could not recognize nor assign an analysis certificate and safety data sheet of a pharmaceutical product to defined locations of CTD format. This finding is not new since it was already affirmed and recommended by Dewey that students should be presented with real life problems and then helped to discover the information required to solve them (Dewey, 1944). The American College of Clinical Pharmacy (ACCP) indicated also that there is a discrepancy between pharmacy education and the actual environment in which the pharmacist will eventually practice (ACCP, 2000). Similar finding stood out in some international reports about the education and training sector in Morocco (Ndem et al., 2013). It was stated that the efficiency level of Moroccan education system is low, both in terms of quantity as regards enrolment and in terms of quality as regards student learning. Despite the favorable context afforded by the labor market dynamics, it was noticed firstly that vocational training graduates face real integration difficulties, and secondly that there is growing gap between higher education output and the professional jobs available on the labor market. This growing imbalance leads to downgrading and unemployment. To decrease this gap and imbalance, the improvement of curricula and teaching methods remain an important bottleneck ("UNICEF Annual Report 2013 - Morocco,").

The present article (i) provides a description of a small-group Case Method adopted during a tutorial of ‘therapeutic chemistry module’, (ii) reports pre-test and post-test scores, and (iii) describes student impressions on teaching methods used in a section of “therapeutic chemistry module”.

METHODS

The subjects were all students ($n = 65$) enrolled in Year 1 of the pharmacy curriculum in the academic year 2012-2013. Sixty students, who completed the pre-test and the post-test, were included in the data analysis. Five students were excluded because they were absents during the tutorial and/or the post-test.

We planned a 4-hours tutorial in which the Case Method approach was used (Barrows, 1986). The Case Method is one particular approach within the broader spectrum of Inductive teaching methods. These methods present an umbrella term that encompasses a range of instructional methods, including inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching. They have many features in common, besides the fact that they are qualified as inductive, they are all student-centered, meaning that they impose more responsibility on students for their own learning than the traditional lecture-based deductive approach (Prince & Felder, 2006). Moreover, inductive teaching methods encourage students to adopt a deep approach of learning (Coles, 1985 ; Norman & Schmidt, 1992). Similarly, 'problem-based learning' (PBL) does not refer to specific educational method. PBL could have many different meanings depending on the design of the educational method employed and the skills of the tutor (Barrows, 1986). In this paper, we highlight the positives outcomes of the Case Method which conveys a sense of reality through cases to the course material, but also emphasizes the process of learning, the learners' thorough engagement with the case and the role of the facilitator (Burgoyne & Mumford, 2001; Hmelo-Silver CE, 2006).

The tutorial was related to CTD chapter taught in the medicines' specificities section. Students were divided into 9 groups made up of 6 to 8 students each. We minimized subgroups formation by distributing some students to foster cohesiveness. To control between-group variability and to minimize the effect of the subjects' idiosyncrasies, we used our knowledge of subjects' background and characteristics to distribute them over groups.

The complete case was distributed to each group in a dedicated folder at the beginning of the tutorial. Each folder contained also a marker, and three transparencies for oral restitution. The cases were about one medicine but designed in complementary ways. The cases were about an oral bilayer tablet of a nonsteroidal anti-inflammatory active ingredient, ketoprofen. The tablet is double layer comprising a white layer and a yellow layer. The white layer contains ketoprofen quick release, and the yellow one contains ketoprofen extended-release. Each case was designed either in the white layer or in the yellow one or in both (see Table 2). The cases are designed to stimulate discussion among each group members and among the nine groups (Allery, 2012; Duek, Wilkerson, & Adinolfi, 1996; Nicholl & Lou, 2012). In this tutorial, we focused on two kinds of specific educational objectives. The first ones were specific to each case in order to create complementary learning objectives among groups. The second ones are common across the nine cases (see Table 2).

Table 2 Objectives and folders content of the nine tutorial cases

Case N°	Folder content	Specific objectives	Common objectives
1	- Composition tablet bilayer - 2 analysis certificates of ketoprofen (by 2 different laboratories) - Safety Data Sheet of ketorpofen - Monograph of ketoprofen - Flow chart of the white layer manufacturing process	- To criticize the validity of analysis certificates - To verify calculations: batch size, unit formula, equipment capacity, etc. - To verify the "In Process Control" (IPC) parameters	- To identify : monograph, analysis certificate, and safety data sheet; - To assess authenticity of raw materials by using analysis certificate; - To compare specifications of analysis certificate with those of European monograph; - To assign monograph, analysis certificate and safety data sheet to defined locations of 'Common Technical Document' format of 'Marketing Authorization Dossier for Medicinal Products'; Additional behavioral objectives are targeted in this tutorial as follows: - To develop an increased motivation for learning; - To develop interpersonal skills and teamwork spirit; - To demonstrate the ability to synthesize, organize, and disseminate relevant information to audience; - To develop an effective reasoning process; and - To demonstrate critical thinking and problem solving during the short oral presentation of specific cases.
2	- Composition tablet bilayer - Analysis certificate of lactose - Safety Data Sheet of lactose - Monograph of lactose - BSE/TSE and Prion free Certificate of lactose - Flow chart of the yellow layer manufacturing process	- To verify calculations: batch size, unit formula, equipment capacity, etc. - To understand the administrative requirement for biological pharmaceutical ingredients : security for human health - To verify IPC parameters	
3	- Composition tablet bilayer - Analysis certificate of gelatin - Safety Data Sheet of gelatin - Monograph of gelatin - BSE/TSE and Prion free Certificate of gelatin - Flow chart of bilayer manufacturing process	- To enhance students assimilation of quality assurance system. - To find out and administrative requirement for biological pharmaceutical ingredients (security for human health) - To analyze critically manufacturing process	
4	- Composition tablet bilayer - For yellow layer: 6 analysis certificates, 6 Safety Data Sheets, and 6 monographs of ketoprofen, HEC, calcium hydrogen phosphate dehydrate, Riboflavin-5'-phosphate Monosodium, magnesium stearate, water.	- To distinguish and gather documents of each pharmaceutical ingredient - To correspond English names of pharmaceutical ingredients to French ones	
5	- Composition tablet bilayer - For white layer: 7 analysis certificates, 7 Safety Data Sheets, and 7 monographs of ketoprofen, lactose, starch, silica, water, gelatin, magnesium stearate - 2 BSE/TSE and Prion free certificates (lactose and gelatin)	- To distinguish and gather documents of each pharmaceutical ingredient - To correspond English names of pharmaceutical ingredients to French ones	
6	- Composition tablet bilayer - 2 analysis certificates of ketoprofen (by 2 different laboratories) - Safety Data Sheet of ketorpofen - Monograph of ketoprofen	- to explain analytical technics described in the ketoprofen monograph (characters, identification, tests, and essay) - to compare analytical technics and results between analysis certificate and monograph - to decide if ketoprofen powder tests are compliant with monograph requirements	
7, 8, 9	- Composition tablet bilayer - 2 analysis certificates of ketoprofen (by 2 different laboratories) - Safety Data Sheet and monograph of ketorpofen - Disintegration tablet test according to European Pharmacopoeia - Table of Climate Zones Classification (by WHO) - Tablets, general chapter, of European Pharmacopoeia - Hardness test according to European Pharmacopoeia - Mass uniformity test of single-dose preparations according to European Pharmacopoeia - Dosage uniformity test according to European Pharmacopoeia - Stability results - Protocol of stability study	- To compare conditions described in stability study with those preconized by WHO for Morocco - To identify if the study was conducted on pilot or manufacturing batch - To evaluate stability protocol - To evaluate if stability testing results are in compliance with established guidelines Note: These documents are similar for groups 7, 8, 9, except for: stability results and stability protocol.	

The tutorial was given three weeks after the end of lectures in a large classroom. Students' seats and tables were arranged in nine circles. So that, students were facing one another to discuss and study documents given by the facilitator. The duration and breakdown of the chronologically ordered tutorial activities are shown in Table 3.

Table 3 Breakdown and duration of tutorial activities chronologically ordered

Activities	Duration
Summative evaluation of lecture sessions	30 minutes
Work groups	2 hours
Groups oral restitution – 7 minutes per group	1 hour
Formative evaluation of the tutorial	30 minutes

The professor's role in this tutorial was to facilitate learning as it is described by Malcolm Knowles in the seven elements for an andragogical learning process design (Knowles, 1975; Neville, 1999). To increase students' participation and critical thinking, and to keep discussion focused and productive, the facilitator provided guidance to all students at the beginning of the tutorial. In each group, the facilitator assigned a reporter and a moderator. Around the classroom, the facilitator followed the nine groups by using his personal fact sheets to avoid missing out the key issues (Coelho, 2014 ; Stentoft, Duroux, Fink, & Emme, 2014). Students had researched the learning issues of cases and generated a summary. Starting from group 1 to group 9, the nine reporter students have succeeded each other by presenting orally in seven minutes the case via an overhead projector. If any student misunderstood something, s/he was allowed to ask questions orally at the end of the presentation. Both the reporter and the group members could answer. Whenever the need aroused, the facilitator intervened by clarifying the missing question. Then, the facilitator led a class discussion to address additional comments and answer further questions. The ultimate objective is to identify the relevant information to retain.

In order to verify and to determine how these cases may supplement each other and enrich pharmaceutical skills in the module-3 of CTD area, it was relevant to conduct two tests within the tutorial. The pre-test was administered at the beginning of the tutorial, and the post-test was done at the end. We informed students that they would take a pre-test and a post-test but did not point out they would be similar in content. Each one of the tests was two double-sided pages long, including six items presented as five short-answer questions and one problem in the stability analysis of active ingredient (See Table 4).

Table 4 - Topics and scores of pre-test and post-test

	Items	Topics	Score (out of 20)
Pre-test and post-test	SAQ1-1	Identify and determine the analysis certificate interest	1
	SAQ1-2	Identify and determine the monograph interest	1
	SAQ1-3	Identify and determine the Safety Data Sheet interest	1
	SAQ2	Determine if polarimetry is available as technic to identify ketoprofen	2
	SAQ3	Determine statement of lactose solubility according to its chemical structure.	1
	SAQ4	Assign documents of the SAQ1 to defined locations in CTD format of Marketing Authorization Dossier for Medicinal Products	6
	SAQ5-1	Analyze an extract of Ketoprofen European monograph – identification technics	2
	SAQ5-2	Analyze an extract of Ketoprofen European monograph – importance of test C as primary identification method	1
	SAQ5-3	Analyze an extract of Ketoprofen European monograph – listing of all the methods advocated in pharmacopoeia for Test A	1
	Problem	Analyze an extract of stability results	4

Legend:
SAQ : short-answer questions

At the end of the tutorial, we used an anonymous questionnaire to survey students' impressions and opinions about the overall course. The questionnaire included a free section for additional comments and suggestions. Only the section related to the medicines' specificities in the 'therapeutic chemistry module' was surveyed. The other sections of the module were not concerned by this survey.

We processed and analyzed data using SPSS ver. 13.0 statistical software for Windows (Inc., Chicago, IL). Data are presented as means (SD). The level of significance for all tests was set at $p < 0.05$. The statistical comparison of the scores between the pre-test and post-test was performed as related groups of asymmetrical quantitative distribution using a Wilcoxon signed-ranks test.

RESULTS

Sixty students were eligible for study inclusion. The attendance rate was 92.3%. The mean student grade for the pre-test was 6.87 (SD=0.39) out of 20 (median 7.0). The mean student grade for the post-test was 13.48 (SD=0.33) out of 20 (median 14.0). In the pre-test**,** 78.3 % of the students obtained a score less than 10; 18.3% obtained a score between 10 and 12; and

1.7% obtained a score between 12 and 14. In the post-test, only 5% of students obtained a score less than 10; 15% obtained a score between 10 and 12; 28.3% obtained a score between 12 and 14; 25% obtained a score between 14 and 16; 25% obtained a score between 16 and 17; and one student obtained 19. The details of undefined, wrong, and true answers of all short-answer questions (SAQ) and also of the stability problem of the pre-test and post-test are shown in Table 5 and Figure 2.

Table 5 - Details of student answers in the pre-test and post-test

		Number (%)			
		True answer	Wrong answer	Undefined	*p*
SAQ1-1	Pre-test	4 (6.7)	54 (90)	2 (3.3)	< 0.001
	Post-test	38 (63.4)	22 (36.7)	-	
SAQ1-2	Pre-test	18 (30)	40 (66.7)	2 (3.3)	< 0.001
	Post-test	49 (81.7)	11 (18.3)	-	
SAQ1-3	Pre-test	5 (8.3)	53 (88.3)	2 (3.3)	< 0.001
	Post-test	46 (76.7)	14 (23.3)	-	
SAQ2	Pre-test	17 (28.3)	28 (46.7)	15 (25)	< 0.001
	Post-test	50 (83.3)	9 (15)	1 (1.7)	
SAQ3	Pre-test	9 (15)	49 (81.7)	2 (3.3)	< 0.001
	Post-test	50 (83.3)	10 (16.7)	-	
SAQ4	Pre-test	55 (91.6)	4 (6.7)	1 (1.7)	= 0.001
	Post-test	58 (96.6)	1 (1.7)	1 (1.7)	
SAQ5-1	Pre-test	48 (80)	12 (20)	-	= 0.001
	Post-test	52 (86.7)	8 (13.3)	-	
SAQ5-2	Pre-test	5 (8.3)	55 (91.7)	-	< 0.001
	Post-test	32 (53.3)	23 (38.3)	5 (8.3)	
SAQ5-3	Pre-test	11 (18.3)	49 (81.7)	-	< 0.001
	Post-test	29 (48.3)	23 (38.3)	8 (13.3)	
Problem	Pre-test	4 (6.7)	56 (93.3)	-	< 0.001
	Post-test	33 (55)	20 (33.3)	7 (11.7)	

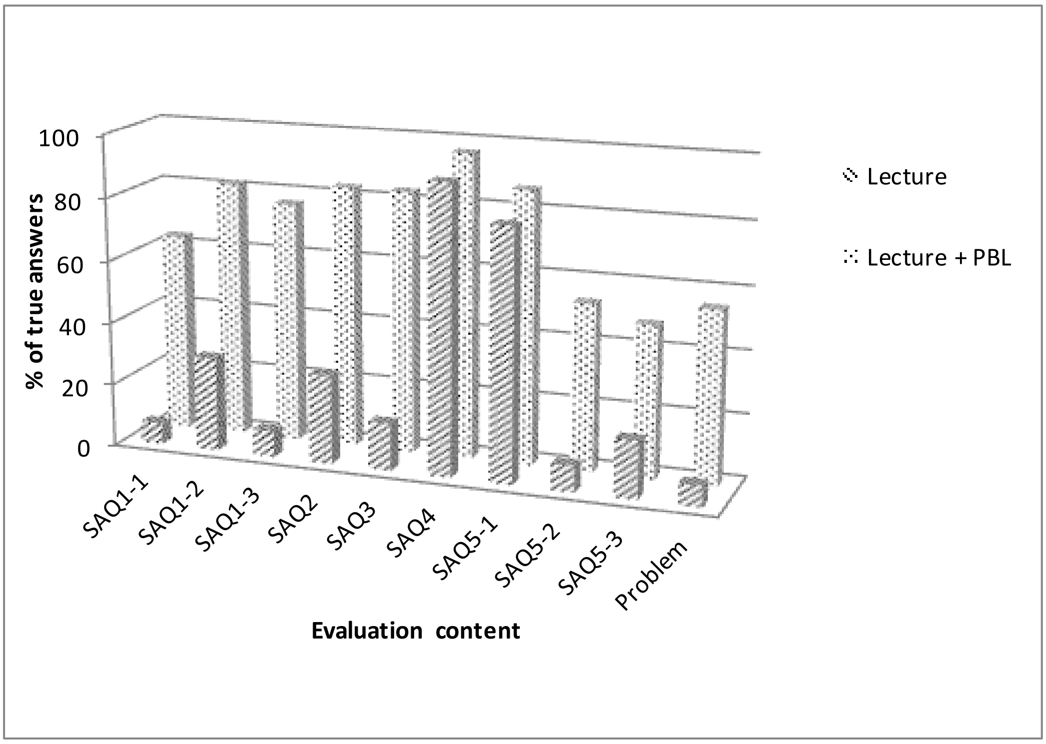

Figure 1: Student performance on the pre-test and post-test

Students' impressions on the teaching methods used in a section of "therapeutic chemistry module" are presented in Table 6 (n=65; response rate 92.3%). Responses were based on a 4-point scale: 1 = always, 2 = Often, 3 = Seldom, 4 = Never.

Table 6 - Student impressions on the teaching method used in the 'therapeutic chemistry module'

	%				
Survey questionnaire items	**Always**	**Often**	**Seldom**	**Never**	**Blank**
The professor announces the specific learning objectives	93.33	1.67	1.67	-	3.33
The professor encourages questions and comments	60	18.33	5	3.33	13.33
The professor provides assistance in case of misunderstanding	53.33	33.33	6.67	-	6.67
The professor asks questions individually to students	13.33	30	25	10	21.67
The professor asks questions to the entire class	60	23.33	3.33	1.67	11.67
The professor encourages students to interact	45	20	8.33	1.67	25
The professor uses examples	41.67	36.67	5	1.67	15

Of the 19 (31.6%) respondents who made suggestions in the free section included at the end of the questionnaire, many expressed their views regarding the adoption of the active learning approach as well as the methodology of the Case Method. Five students appreciated the Case Method as a complementary method to traditional teaching methods. One student stated that folders should be distributed to groups prior to the tutorial in order to present adequately the summary generated during oral presentation. One student suggested that the number of hours allocated to teaching by Case Method should be increased. Another student commented that this tutorial was the first time when students enjoyed working on their assignments as a team. A fourth student stated the tutorial allowed them to assimilate many important concepts. The rest of students, however, pointed out that more details are usually provided in the lectures part.

DISCUSSION

The first part of this study is related to the 4-hours tutorial planned for the first year of pharmacy curriculum. This tutorial highlights the positive outcomes of the Case Method through two tests. The pre-test made a summative evaluation of the lectures whereas the post-test measured students learning progress just after the tutorial. The first outcome is related to the improvement of student integration of the course materiel. Indeed, students' performance on the post-test (13.48 out of 20) was significantly higher than those on the pre-test (6.87 out of 20). These results corroborate findings of previous researches, since PBL led to significantly improved test scores compared with lecturing as a traditional mode of teaching (Cheng, Alafris, Kirschembaum, Kalis, & Brown, 2003; Cisneros, Salisbury-Glennon, & Anderson-Harper, 2002; Klegeris & Hurren, 2011; Romero, Eriksen, & Haworth, 2004, 2010; Ross et al., 2007; Shaw, Gerrett, & Warner, 2006). The second outcome is related to enhancement of students' thinking and their problem-solving skills despite the limited duration of the tutorial. Indeed, through audience students' pertinent questions, and relevant oral presentation of each specific case, we have noticed that students developed progressively teamwork skills and begun to use reasoning skills critical to solving problems. This finding fits with other studies which highlight that millennial students are more comfortable with a group-based approach to learn (ACPE, 2012; Haworth et al., 1998; Howe & Strauss, 2000; Marshall & Nykamp, 2010; Novak, Shah, Wilson, Lawson, & Salzman, 2006; Pierce & Fox, 2012; Pinder-Grove & Groscurth, 2009; VanLeit, 1995). The third outcome is related to improvement of our experience in term of design, planning, and practice of the Case Method. Indeed, we planned deliberately this tutorial three weeks after the end of lectures because the average period between the end of lectures and written examination of the module vary from two to three weeks. The aim targeted was to simulate conditions of written examination and see if students still memorized the relevant information of lectures. The duration was limited to four hours, since it was the first experience in this kind of teaching method both for the professor and students. Moreover, we felt that it would be pertinent to introduce progressively the Case Method as teaching method; especially for some students who are much accustomed to lectures mode of learning (Borrego, Rhyne, & Hansbarger, 2000; Wood, 2003). The cases' preparation was quite difficult since we focus on two contradictory objectives: complementary cases with similar objectives. To generate carefully the nine cases, we spent more than three months. We were assisted by Rabat Laboratory of Medicinal Chemistry professors and PhD in the National Laboratory of Medicines Control. Other challenges are time and money consuming and worth be cited like the time slot reservation, the rearrangement of the classroom furniture, the printing of documents for each case outside of College, documents' classification within folders, etc.

The second part of this study is related to the overall positive students' impressions that stand out on the survey questionnaire of the teaching method. We adopt in lectures a mix of deductive teaching, examples, and inquiry-based teaching; because we believe that, in practice, neither teaching nor learning is ever purely inductive or deductive. Learning process involves movement in both directions and good teaching helps students learn to do both (Prince & Felder, 2006). Moreover, to give students the main thread, we outline the specific objectives at the beginning to help students to follow the professor; and at the end of the session to verify if students reach these objectives. Thus, 93% of students noted that "The professor 'always' announces the specific learning objectives". For the inquiry-based teaching, 60% and 23% stated respectively that the professor 'always' and 'often' "asks questions to the entire class"; also 60% and 19% of students stated respectively that "The professor 'always' and 'often' encourages questions and comments". But only 45% of respondents indicated that "the professor 'always' encourages students to interact" while 25% prefer do not respond to this question. To explain these results, we could say that the professor had noticed previously that some students were reluctant when she adopted an inquiry-based teaching. This reluctance could be explained by resistance to this teaching method, shyness, lack of self-esteem, or fear to talk nonsense, or their beliefs that the teacher's job is to transmit knowledge to students (Valtanen, 2014). Whatever the reason, to clarify any student' incomprehension the professor appealed to a paper notebook. This notebook moves among students, and is collected by the professor at the end of each lecture session. The professor analyzes students' questions, and provides more explanations at the beginning of the following lecture session. Hence, 53% and 33% of students ranked respectively that "The professor 'always' and "often" provides assistance in case of misunderstanding". In order to measure the impact of examples used in the course, we integer this item in the questionnaire. Thereby, 42% and 37% of students stated respectively that "the professor 'always' and 'often' uses examples". Actually, the professor illustrates lectures by examples like the extract of European monograph, analysis certificate, Safety Data Sheet. Nevertheless, the pre-test results confirm that using examples only did not ensure an effective assimilation of the course; since 90% did not recognize the monograph extract, 66% could not identify the analysis certificate and 88% did not manage to identify the Safety Data Sheet. This finding is similar to those demonstrated in previous researches which confirm that students exposed to worked examples are not able to solve problems with solutions that deviate from those illustrated in the examples. Also, they cannot clearly recognize appropriate instances in which procedures can be applied, and have difficulty solving problems for which they have no worked examples (Atkinson, Derry, Renkl, & Wortham, 2000).

Above, we have seen how students reach more behavioral skills and higher scores after the Case Method tutorial. We could state that there is clearly a need to extend active methods to the other sections of “therapeutic chemistry module” or even to other pharmaceutical modules. However, it would seem essential to state that, in this kind of teaching methods, professor should make explicit connections for students with both the teaching and the learning processes; connections that students are required to reflect upon in light of their own future teaching practice (Murray-Harvey, Pourshafie, & Santos Reyes, 2013). If not, several difficulties could arise such as students’ negative perceptions, dissatisfaction with group work, etc. (Holen, 2000). Thus, we admit that professors, especially in our context, need to acquire complex teaching competences which involve knowledge, skills, engagement and personal commitment. This could be possible only by implementing regular workshops and training sessions in the pedagogy field (Coelho, 2014). The new reform of pharmaceutical studies, which is going to be applied in the next academic year 2015-2016, would represent an excellent opportunity to plan these workshops and training sessions for professors in the active pedagogy field.

This work has several major limitations. The pre-test and the post-test was not administered after the same gap period of time which is in our context three weeks. The pre-test was administered three weeks after the end of lectures while the post-test was administered immediately at the end of the tutorial. The number of hours allocated to this tutorial is limited. The questionnaire survey does not distinguish between tutorials and lectures.

CONCLUSIONS

As it was verified through the Case Method tutorial, active teaching methods encourage students to adopt a deep learning and impose more responsibility on students for their own learning. To implement active teaching methods, trained facilitators have to guide students rather than to teach them. The new reform of pharmaceutical studies, which is going to be applied in the next academic year 2015-2016, would represent an excellent opportunity to plan regular workshops and training sessions for professors in the active pedagogy field.

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The Aalborg University PO-PBL Model from a Socio-cultural Learning Perspective

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ABSTRACT

Since the 1970's, Aalborg University has been developing a new pedagogical model in higher education: The Project Oriented – Problem Based Learning (PO-PBL). In particular, the Faculty of Engineering and Science has developed a pedagogical proposal that introduces students to a different type of learning. One of the theoretical frameworks underpinning the understanding of learning is the socio-cultural perspective. This paper aims at exploring and analyzing the PO-PBL model from this theoretical perspective. In addition, this reading may also open a new viewpoint in science teaching for other universities.

Keywords: Project Orientation-Problem Based Learning (PO-PBL), socio-cultural perspectives on science, science education at university level.

INTRODUCTION

The term "innovative university" seems redundant. A university is obviously an innovative institution in knowledge production. Nonetheless, universities also perpetuate academic traditions, particularly as far as teaching is concerned. Founded on the research-based university model introduced in 1809 by Humboldt in Berlin; it can be described as providing

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education to professional elites in which academics are researchers who engage in the production of new knowledge, with a high specialization of subjects and disciplines (Bowden & Marton, 1998). In the last decades, the consolidation of a globalized knowledge society has been related to the expansion of higher education. Universities are expected to equip a growing number of people with competences, knowledge and even research capabilities to perform different jobs in both public and private organizations. The challenge for universities is closing the gap between innovative knowledge production and innovative teaching and learning processes.

In response to such challenges, during the last four decades Aalborg University (AAU) has been conducting an educational revolution that opens university level education to a broader target of students, using the Project Organized – Problem Based Learning model (known as the Aalborg PBL model but here referred to as the PO-PBL model to highlight its special characteristics).

The PO-PBL curriculum works with disciplinary content and competences; examples of competences include learning to learn, group work, define and delimit complex problems, use different resources and theories to propose a solution, and critical thinking. In this sense, it is important for higher education pedagogy to improve its understanding of the learning process in this university, because its practice has shown an effective way of introducing and implementing an education suited to current social and economic demands (Kolmos & Holgaard, 2010).

In different documents and academic writings there are general descriptions of AAU's pedagogical practices and a number of learning theoretical concepts that are useful to consider in relation to the PO-PBL approach. However, these writings do not represent a full or unified theorization of PO-PBL as university pedagogy. Of course, there are many descriptions in Danish of the PO-PBL model, its principles and practices, but these descriptions are far from providing a comprehensive philosophy and theory for university pedagogy. Moreover, few of these descriptions have been translated into other languages making it difficult to adapt the model to other contexts. In addition, most of the existing conceptualizations of the model are based on individual-centered theories of learning (Laursen, in Kolmos, A, Fink, F. K., & Krogh, L., 2004, L; Laursen, in Kjær-Rasmussen, L. K., & Jensen, A. A., 2013) which fall short in grasping the potential for learning of the group-based organization of project work and its problem orientation. Therefore, to develop a theoretical framework for the current model, we find it necessary to introduce a socio-cultural perspective of learning to understand the basic elements of PO-PBL. As we will show, this theory provides a background to explain the benefits of key practices used in the Aalborg model.

For this reason, our purpose is to analyze the PO-PBL Aalborg University model implemented in its Faculty of Engineering and Science from a socio-cultural perspective of learning. Then, from this analysis, we intend to generate an alternative view of this model that may be more useful for other universities. To achieve our purpose, this document is structured in four sections. First, we introduce and describe the Project Oriented - Problem Based Learning (PO-PBL) model as a general pedagogic practice in higher education at AAU. In the second section, we present a socio-cultural perspective of learning in the context of university pedagogy. Then, in section three, we use this theoretical perspective to generate an alternative view of the PO-PBL Aalborg model of the Faculty of Engineering and Science. Finally, we discuss different possibilities to make these university educational practices available to other universities, so that more people can build more and probably better competences.

THE PO-PBL AALBORG MODEL: A NEW UNIVERSITY CURRICULUM

Currently, it is clear that higher education is fundamental for present and future generations. The challenge to educate people to be creative, adaptive and with the ability to work in interdisciplinary teams is huge because these competences are new requirements for professional fields. Therefore, the curricula that have traditionally focused on the acquisitions of disciplinary content urgently need to be reviewed. Some institutions have made progress in this sense and currently have educational approaches that can address this challenge.

In Denmark, the context of youth and cultural movements of 1968 in Europe was important for the creation of higher education institutions that challenged the traditional, elitist patterns of academic authority through the concentration of knowledge in the hands of the "professors". Their pedagogical proposal led to a de-centering of the disciplinary knowledge through the construction of innovative curricula and student-centered ways of teaching in many professional fields. This was how the fourth and fifth Danish universities were founded: Roskilde University (1973) and Aalborg University (1974); both developed the Project Organized – Problem Based Learning model as a strategy to carry out a revolution in higher education (Vithal, Christiansen, & Skovsmose, 1995).

Aalborg University established its PO-PBL model simultaneously in its three faculties —The Humanities, Social Sciences, and Engineering and Natural Sciences— covering all their fields of study. Then, since 2010, the new Faculty of Medicine also adopted and adjusted the model to its programs. Vithal, Christiansen and Skovsmose (1995, p. 200) present a concise description of the Aalborg University model:

> All students work in project groups which function as work units. The groups normally consist of four to five students from a specific study programme. A supervisor is assigned to each project group. Each semester, the students prepare a project report, whose topic is within a given framework. Project topics may be suggested either by students or by teachers. The project work generally takes 50% of

the study time and another 50% is devoted to courses. Some of the courses are related to the topics of the semester and others serve as direct support to the project work. At the end of each semester, the project is presented in a written report, which is evaluated orally by the supervisor of the group and an internal or external examiner.

In this project, the students have to choose a general subject to work on from range of proposals provided by the group of supervisors; these subjects reflect the principal issues considered in the semester curriculum. The learning process begins when the students formulate a problem on this subject, and continues with the process in which they try to solve it (Kolmos et al., 2004; Ravn, 2008; Vithal et al., 1995). This long-term process (usually for a semester) working with self-defined problems gives the opportunity for students to integrate concrete experiences and empirical research with the theoretical elements of their study. In this way, the students are expected to attain a deeper comprehension of the mandatory topics of the curriculum and to gain experience on some selected and complex problems. This experience is the ground for learning to re-contextualize forms of knowing and acting in fields that are new or related to their subject in a more proficient manner (Ravn & Valero, 2010).

However, the university started developing on the basis of a number of theoretical principles, which have found their way to a pragmatic development (Kolmos, Fink, & Krogh, 2004). In 2010, Barge suggests that the diverse practices generated in the different fields of study have common elements that place them under the umbrella of a general model (Barge, 2010). However, the understanding of these theoretical principles may vary in each department, and these differences will change aspects of the programmes.

For example, Vithal, Christiansen and Skovsmose (1995) present and discuss four core principles on the PO-PBL model: the problem-orientation, the interdisciplinarity, the participant-directed studies, and the exemplarity principle. Kolmos, Fink and Krogh (2004) consider that other principles are learning by doing, learning using own experience, working with others, strong relation between theory and practice, interdisciplinarity and exemplarity. It is not our purpose here to discuss which are the proper principles to describe the model, but rather we intend to enlighten the meaning of these principles using a socio-cultural perspective of learning to analyze the PO-PBL model, in particular in relation to the Faculty of Science and Engineering. For this purpose, we chose the view of Vithal, Christiansen and Skovsmose's on the PO-PBL for our analytical exercise. Further on, we will present their conceptualization of the PO-PBL principles, but first we introduce our specific perspective from the socio-cultural view.

THE SOCIO-CULTURAL PERSPECTIVE OF LEARNING

The socio-cultural perspective of learning is a broad conceptual field that addresses human learning: It is “a cluster of theories that share a premise that learners and social organizations exist in recursive relation to one another” (Beach, 1999, p. 104). A common origin for many of these theories is Vygotsky’s cultural-historical psychology (1978, 1986) about the origins of human thinking being inseparable from social and cultural praxis. This perspective of learning suggests that knowledge is a process resulting from negotiation of meaning, coming from the social activity of individuals, and encompassed by a cultural framework (Radford, 1997, 2008). In this sense, disciplinary knowledge is historically generated during the course of the disciplinary activity of individuals, and fixed patterns of reflexive human activity mediated by artifacts: objects, instruments, sign systems, etc. (Radford, 2008), in institutional settings. For higher education this implies that the knowledge and forms of knowing developed by university staff in their research, historically and in the present, constitute the practice within which individual meaning is negotiated in relation to the other participants in the practice and with the help of its artifacts.

In consequence, learning occurs as a social process —praxis cogitans— through which students become progressively conversant with cultural forms of thinking, being and reflecting mediated by language, interaction, signs and artifacts (Radford, 2008), and the connection between knowing and being is fundamental. In this sense, it is the elaboration that the student does of a reflection; this reflection is defined as a communal and active relationship with the student’s cultural-historical reality (Radford 2008). This implies that learning is not considered an individual and isolated enterprise; it is distributed and transformed among members of the community with diverse expertise and through their action within it (Lave & Wenger, 1991; Wenger, 1998). Also, in a specific activity, the participants’ roles could be complementary or with some leading and others supporting or actively observing, and may involve disagreements about who is responsible for what aspects of the endeavor (Rogoff, 1994) .

In particular, Leach and Scott (2003) argue that adopting a socio-cultural perspective on science education implies viewing science, science education, and research on science education as human social activities conducted within institutional and cultural frameworks. Radford (2008) shows that it means seeing the scientific study of the world itself as inseparable from the social organization of the scientists’ activities. These ideas involve rethinking the ways of learning and teaching science at all educational levels, particularly at the university level.

As universities and professional work environments have very different cultures, activities, discourse and affordances, there is naturally some disconnection between the knowledge, skills and attitudes developed in traditional university courses and the work of different professions (Sutherland & Markauskaite, 2012). On one hand, Northedge (2002) argues that academic communities constitute a special case in that they are spatially and temporally dispersed, with core practices enacted largely in writing textual 'fora' such as journals. On the other hand, the way members of the profession interact and the way they use language, tools and sign systems is particular for each career. Closing this gap and preparing new graduates for a transition into the work place are important challenges for professional education. Part of this preparation involves the development of a professional identity: understanding themselves as professionals and their interactions within this professional world (Dahlgren, Hult, Dahlgren, Segerstad, & Johansson, 2006; Sutherland & Markauskaite, 2012). In this sense, the insights and skills required for learners to become members of these communities are as much social and cultural, as intellectual and content-oriented.

From this sociocultural perspective, authentic learning experiences allow students to begin to engage with some of the routines, rituals and conventions of their profession, so that as part of their education they also acquire some of the values, skills and knowledge associated with their professional practice (Sutherland, Scanlon, & Sperring, 2005). An important development of this vision has been carried out in teacher education programs because there is a high demand on bridging studies at the university with the preparation for exercising the teaching profession (Sutherland et al., 2005; Sutherland & Markauskaite, 2012).

At Aalborg University, in the last decade, some inspirations from the socio-cultural learning approaches, especially Wenger's concept of *community of practice* (Lave & Wenger, 1991; Wenger, 1998), have been used to describe specific processes in the PO-PBL model. For Wenger (1998), the term community of practice comes from the idea of learning as social participation, and it refers to the process of social learning that occurs when people who have a shared practice collaborate over an extended period to share ideas, values, beliefs, languages, and ways of doing things. Learning involves travelling along a trajectory from the periphery to the center of this community and becoming a full member with legitimate participation in it. For example, Du (2006) analyzes how both male and female students develop their engineering identities in the process of studying engineering in a PO-PBL learning environment. In the field of human-centered informatics Dirckinck-Holmfeld and collaborators (2004) interpret the design of a master's program through PO-PBL pedagogy using the concept of communities of practice. These theoretical tools provide insights for designing learning communities, and cultivating them (Dirckinck-Holmfeld et al., 2004). Coto and Dirckinck-Holmfeld (2008) used these ideas in a research project to facilitate communities of practice among university staff as part of their pedagogical professional development, addressing the introduction of information and communication technology (ICT) and PO-PBL approaches into teaching and learning at the university level (Coto Chotto, 2010).

However, in our perspective, the possibilities for interpreting and re-signifying education practices at Aalborg University from the perspectives offered by the socio-cultural approach can be extended. In the following section, we will present a broader analysis from the socio-cultural learning perspective of key elements in the PO-PBL model as it is used at the Faculty of Engineering and Science.

LOOKING AT THE PO-PBL MODEL WITH SOCIO-CULTURAL LENSES

As we previously presented, there are many different descriptions of the learning principles under the PO-PBL model, but here we will use three theoretical dimensions from the socio-cultural theory to analyze it: the problem in a project as a real context for *praxis cogitans*; interactional processes and mediation as ways of learning; thinking, reflecting and becoming as a continuous progressive re-contextualizing of knowledge and competence. Although these dimensions are not separated from each other, for analytical purposes we will work on each of them separately. Our analytical strategy combines discussions on each principle and illustrations of their operation in particular cases of a group of students and their PO-PBL practice.

The Problem in a Project as a real context for praxis cogitans

The second principle for Vithal, Christiansen and Skovsmose (1995) is the *interdisciplinarity*. This concept is derived for the problem-oriented studies because the most interesting problems usually require drawing from different disciplines. Additionally, interdisciplinarity promotes an integration of ways of thinking, doing and being in different disciplines, which are isolated in the traditional approach to university teaching. This integration fosters a deeper understanding of these practices, an additional ability to move in various disciplines and offers different perspectives within the disciplines.

Vithal, Christiansen and Skovsmose (1995) argue that the idea of problem-oriented work in the PO-PBL model is the most important element of project work as stated by one of the key figures in the Danish development of the model, Knud Illeris

> *The central feature of problem-centered instruction is that it does not originate in the subjects themselves - which have been developed through tradition, the basis of which is far in the past and dependent upon societal conditions which long since have vanished - but in currently relevant problems which are addressed using knowledge, methods, and theories from different disciplines to the extent they are relevant to the problems. (Illeris, 1974, p. 81, Vithal, Christiansen and Skovsmose's translation).*

This idea is completely in line with the socio-cultural perspective, because a problem only exists in a social-historical context and it expresses contrasts or conflicts in a specific culture or view of the world. For example, Leach and Scott (2003) show that the development of scientific knowledge (which involves the resolution of problems and the generation of new ones) is not only constrained by empirical data, but also socially validated by the scientific community. When the students choose to study real phenomena of their own interest, and make all final decisions according to the resources and materials to be used to develop the study, they are in a similar position to that of the scientists (Roth, 1995).

In the Aalborg PO-PBL the project and the problem are inseparable. Vithal, Christiansen and Skovsmose express that the problem-oriented pedagogy of the PO-PBL begins with the students formulating a problem. However, it is often not possible to formulate a research problem early in the project. Instead, the original problem must be refined through continuous studies until it is a functional part of the research process, and an important part of the project work fulfils this purpose. Thus, in the Danish version of the PO-PBL model the problem and its solution develop as two aspects of the same process, and in the end, when the problem has been accurately formulated, it is because it has been solved (Olsen, 1993, translated from Danish by Vithal, Cristiansen and Skovsmose).

In opposition to a traditional science or engineering class that works on relatively well-defined problems and where the students construct specific solution strategies, students in the PO-PBL model are motivated to think more about the questions than about the answers (Kolmos, 2004). It is important because recognizing emergent problems in rich problem-solving contexts is a crucial skill in scientific inquiring (Roth, 1995).

Furthermore, the learning process is organized around the project. The project is a complex effort in groups: students should be organized to define a *problem* and try to find a solution within the specific purposes of the semester. This involves making decisions in groups for different areas of the project that must be completed at a deadline determined in advance; this includes collecting information, meeting with the supervisor, defining procedures, writing the report, etc.

Another very important part of the project is that it must be developed within a particular social context and considering ethics. The students are not only learning to pass evaluations and progress in their careers, but to be active members of the society and participate in work environments outside the university.

From a socio-cultural perspective, the Aalborg duality of problem-project reflects the activity in scientific and engineering environments. In many cases, the boundaries between science and engineering are unclear, so what happens in science might as well be used in engineering and what happens in engineering could inspire the development of science. For scientists, science progresses by means of research projects. Usually, they are long-term projects and involve small projects on one area of science specialization and few people –normally Master's and PhD students- working in them. Roth (1995) shows that to actually learn science, students should experience some aspects common to scientific activities such as:

identifying problems and solutions and testing these solutions; designing their own procedures and data analyses; formulating new questions; and experiencing the social nature of scientific work.

Mills and Treagust (2003) summarize that the term “project” is universally used in engineering practice as a “unit of work”, usually defined on the basis of the client, and almost every task undertaken in the professional practice by an engineer will be in relation to a project. Projects may vary on time scales and complexity, but all will relate in some way to the fundamental theories and techniques of an engineer’s discipline specialization. Successful completion of projects in practice requires the integration of all areas of an engineer’s undergraduate training.

In consequence, the problems in the PO-PBL projects can be conceived as an actual social practice, consistent with key elements in the scientific or engineering activity, and an opportunity to learn these disciplines in their complexity. Here, activity refers to processes or events that are part of a socially defined division of labour (Leont’ev, 1978; Radford & Roth, 2011; Radford, 2008; Roth & Lee, 2004; Roth & Radford, 2010); i.e. researching to build scientific knowledge, studying to get a degree. Each of these activities involves different rules, tools and social interactions. Activities are general level events: they are carried out by means of concrete goal-directed actions. The object of an activity can only be attained through actions aimed at specific goals. Activity and actions stand in a mutually constitutive relation: Actions presuppose and draw their sense from the activity that they concretely develop; but activity exists only because of the concrete actions. As a result of this dialectic, the same action has a very different sense when a different activity is being carried out. A good example is the sense of mathematical equations and the associated mathematical actions, which may substantially vary between scientists and engineers or technicians (Brown, Collins, & Duguid, 1989; Roth, 2009).

In the PO-PBL Aalborg vision, in each semester – starting in the first year – the students develop an in-depth study of a few core disciplinary contents through their specific project-problems and have time to think and reflect about how to do it in their profession. Vithal, Christiansen and Skovsmose (1995) identify this principle as *exemplarity*, originated in Oskar Negt’s writings (1964); he suggests that it is possible to understand basic structural and political features of society by concentrating on specific social events, which comprise an entry point to a general understanding. In the PO-PBL model, this argument is used to organise the curriculum in relation to authentic problems. These problems have the potential to provide an exemplary understanding of the general problem and by researching them the students will have a deeper theoretical insight. In this sense, a long list of concepts of disciplinary content is not the core of the curriculum. Instead, the curriculum explicitly aims at developing more complex learning objectives; moreover, it supports the relation between the theory and its disciplinary practice.

To illustrate this, we will tell the story of a project developed in 2011 for a seventh semester group of Biomedical Engineering students. The aim of this semester was to collect physiological data and setup an experiment; the written report had two parts: an article and a worksheet report. This group chose to work on a project based on the “Brain Computer Interface (BCI)” technology, and they intended to generate their own data analysis protocol. BCI is a growing research field because the electrical activity generated by ensembles of cortical neurons can be employed directly to control a robotic manipulator (Lebedev & Nicolelis, 2006). The experiments were hard to do because they require safety standards to be performed on human subjects. In a first stage, the group collected different experimental protocols that could be carried out in the university laboratory. They chose a protocol in which a soft magnetic field stimulates some brain areas and generates electrical activity that may be evident in muscular movements. Simultaneously, by working in their project they also learned about cortical neurons, magnetic fields and their interaction with neurons, and ethical aspects on this kind of experiments.

In a second phase, the students learned how to follow the protocols and sought external volunteer subjects to develop the experiments. The measurements were quite risky because the range of response is small and it is difficult to make a difference between the electrical signals generated by the nerves or by the external field. Thus, the volunteers had to attend six or seven sessions: the first three were to get used to the protocol and the rest to actually take measurements. In addition, the students studied different types of analyses to consider if they could produce divergent results, and developed their own protocol. Next, the group analyzed the data using two protocols: their own and one from their literature review. Finally, they wrote down the documents related to problem-project and project report. The article had the usual structure of a scientific paper (20 pages), but the worksheet report included a discussion about the choice of the data analysis protocol, and a deep reflexion on ethical considerations in the conduction of the experiments (70-80 pages).

This experience shows different achievements; first, the students were able to conduct actual scientific activities; second, the core of learning got the students involved on this activity beyond simply covering disciplinary contents or specific kinds of protocols. In this sense, the problem in the project can be seen as an authentic learning experience where the students begun to engage in some of the routines, activities, discussions and conventions of their profession.

Next, we will focus on how language, artifacts and interaction mediate learning.

Interactional Processes and Mediation as forms of learning

As we presented earlier on, the PO-PBL model is a student-centered view of teaching. It implies a different relationship between teachers and students. In the project, most of the learning processes take place in groups or teams where students continuously discuss, negotiate and learn from each other in their project work processes. At the same time, the teachers play the role of supervisors and in the Danish context their function is to facilitate the learning process (Kolmos, Du, Holgaard, & Jensen, 2008). This role is complex because the teachers are not the "project leaders" that direct the students; they better resemble a more knowledgeable person that aids a less experienced novice in the integration of professional knowledge and actions. It suggests a more balanced power relationship between teachers and students and a more open-minded teacher that helps the students to cope with insecurity and guides them in start-up and closing processes more than being the expert that teaches the disciplinary content.

Vithal, Christiansen and Skovsmose (1995) show that *participant-directed* studies were born as a reaction against the power of the professors. Therefore, it does not mean that the students are alone or in absolute control; the supervisors are also participants and their experience is fundamental for the process. Furthermore, the group work encourages discussions that are helpful for problem clarification, analysis, synthesis and critical evaluation of the work; it also encompasses the meta-learning process and psychological support that students can provide to each other.

In addition, the projects are developed in appropriate spaces: every group has a room with all they need in order to create a good working environment, access to laboratories where experiments can be carried out if it is necessary, the library and on-line resources.
According to the socio-cultural theory, learning is mediated by interaction, language and artifacts. Both types of interactions – students/students and students/teacher – have a central role in the learning process; nevertheless, the use of laboratories, books, articles, etc. constitutes an interaction with the artifacts in these disciplines or professions that are not divorced from the interactions between people. To develop this idea we can use the example in the previous section, presenting a meeting between the supervisor and the group in the laboratory. The regular place for meetings was the group room, but considering the goal of the semester, a meeting in the laboratory was the opportunity for a more contextualized disciplinary contact with the supervisor.

The students had studied the techniques of data collection and this particular meeting was intended to check the ability of the group to perform the experiments correctly and safely; if that was accomplished, the group was ready to continue with the experiments on external volunteers. The meeting took place as role-play where the supervisor acted as a "new volunteer" for a set of experiments and the students were the "experts" that explained and introduced the volunteer into this practice. They worked in couples that were switched during the experience, but the whole group was keeping up with all the proceedings. A student began to tell the volunteer that they would be explaining what they were doing and what she could feel, and that they would ask a lot of questions to make sure she would be fine. And, if she had any questions or felt uncomfortable in any way, she should tell them.

Next, a couple placed some electrodes on specific parts of the body (fig 1a) and then turned on the machine that generated the magnetic field (fig 1b). The students described the procedure all the time and the supervisor took different roles: first, as the subject of experiments, and therefore did not comment on the experimental work; she asked more about her body's reactions and sensations. Secondly, as the knowledgeable advisor who gave suggestions on what could be improved. For example, she commented on the pressure applied on the head, which was too hard and the students needed to keep asking about it to guarantee that the volunteer was comfortable. Third, as the examiner, who checked the knowledge of the students by asking them what they would do in case the subject fainted. Meanwhile, the other couple verified on the computer that the system was collecting data properly.

At one point one electrode was not in the right place; one of the students working with the computer noticed it and made an intervention. He adopted the position of the volunteer and told his partner where the electrode should be placed (fig 2a, 2b). The supervisor asked what would happen if an electrode was not well located, and the student that made the intervention answered that the system would not be able to collect the actual muscular response and explained why this would be detrimental to the experiment. Then, the students went back to their original task. On this dynamic, the students developed a complete set of actions, and the supervisor was able to switch between the described positions depending on the moment. There were short suggestions naturally interwoven in the process, for instance, with an open formulation: "have you thought about …" to reflect with them about a particular knowledge; "when you do this, do you then…" - an example of supervision aimed at stressing that they are observant in relation to the subject in the experiment.

Figure Pictures of the group work session in the lab. **1a.** The entire group with the supervisor as a new volunteer for the experiment. **1b.** The students perform the planned experimental protocol. **2a-2b.** The learning process is mediated by language: oral and body expressions of the activity that is learned.

In this example, the learners become effective participants in this engineering practice through the use of a specialized discourse, artifacts and procedures. We want to note how the interaction with the lab equipment (artifacts and tools) is constant and can often be considered as tacit. However, the activity will be impossible to do outside these concrete conditions. Much of the conversation happens around the expected use of these engineering tools.

From the socio-cultural theory, students fully appropriate the way a discourse works only through using it to produce meaning of their own (Lemke, 1990). To become a speaker of a discourse is to acquire a new identity as a member of that community and it is critical for the learning process. The teacher is a speaker of the specialized discourse and through tasks and written documents guides the students in the practices of the discourse. To achieve this, Northedge (2002) argues that the first step is that the teacher must be able to go outside the specialized discourse and engage in a dialogue with the students within the terms of a familiar discourse. Then, having initiated a flow of meaning the students will encounter documents, debates, issues and voices that help them develop a sense of the character of the discourse community: how they speak and argue; their core purposes and values; their preoccupations. Finally, through participation they begin to see the force of the theoretical analysis embedded in the discourse. In our example, great part of the supervisor's role was discursive, encouraging new discussions, meanings and reflections about the scientific knowledge and its production with the aim of helping students to appropriate these practices.

However, for Vygotsky (1986) knowledge is collaboratively constructed between individuals on the Zone of Proximal Development (ZPD)

> *The ZPD is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers* (Vygotsky, 1986, p.86).

This definition has been traditionally accepted in educational approaches focused on children, under the assumption that it is only the learner who learns.

Moving further, Roth (1995) understands the ZPD as a construction zone for sharing knowledge or meaning. From this shared construction zone, knowledge can be appropriated by individuals and included in their personal repertories; this process includes both aspects: the situation –culture, its artifacts, tools and language- and the individual. Roth and Radford (2010) expound that ZPD is an interactional achievement that allows all participants to become teachers and learners. From their analysis, each word in the ZPD is the product of social interaction and is mated with a social evaluation. This evaluative role of each utterance is the reason why the teacher can know that the student has or has not understood, and the student can know that he has or has not provided the appropriate response. Who is in the know and who learns is a product *interactionally* and contingently achieved as participants engage with each other. This symmetric space for interaction introduces the idea of *shared understanding* as a social-knowledge that results from this collaboration (Roth & Radford, 2010; Roth, 1995). In addition, far from being a sole opportunity for the student to learn (e.g., subject matter), the *zone of proximal development* is also an opportunity for the teacher to learn too (e.g., reconfigure knowledge in the new setting of the students' project, subject matter pedagogy or subject matter outside the key expertise area but brought into the project by the students). Our example can be read from these same ideas and this perspective opens the possibility to a completely different view on the university teachers' activity and learning not only due to their relevance in the development of the students' voice as we previously suggested, but also because of their own participation as members of the pedagogical community.

Thinking, reflecting and becoming as continuous progressive recontextualizing

Many of the educational researchers who developed the PO-PBL model consider that reflection is fundamental to introduce and highlight the quality, depth and relevance of what is learned (Kolmos et al., 2004). In addition, this reflection has been interpreted as a core part for the students to develop the skill of applying knowledge to new situations. We want to carefully analyze this idea.

Roth (2009) introduces the idea that Schön's notion of reflection-in-action and reflection-on-action can be integrated into a socio-cultural perspective of learning. For Roth, during activity, reflection-in-action is designed to facilitate the interactions in the ZPD: both students and teacher as reflective-practitioners engage together in practical action and talk. As we previously discussed, this dialogue introduces the student to the culture of which both are members. Moreover, Radford (2008) expounds that the reflexive nature of thinking means that the individual's thinking is neither the simple assimilation of an external reality nor a construction. The idea that thinking is a re-flection implies a dialectical movement between a historically and culturally constituted reality and an individual who refracts it (as well as modifies it) according to his/her own subjective interpretations, actions and feelings. In this sense thinking and reflecting are forms of participation in a specific culture.

From this perspective the subjects in the activity systems not only produce outcomes but also produce and reproduce themselves (Roth, 2009). Learning is not just about getting to know; learning is also about becoming someone (Radford, 2008). As a consequence, a PO-PBL student who participates in long-term scientific or engineering projects learns the rules, tools and social interactions, and gradually gains experience in what it means to be a scientist or an engineer with specialized ways of thinking and reflecting that are accepted as valid by other community members. In other words, students are becoming more expert, and legitimate participants of the practices of their professors and lecturers. They are gaining a sense of professional identity while being students as they acquire and participate in the forms of knowing of their professors.

As Roth (2009) shows, it is important to be aware that activity systems offer resources to those who explore and implement the possibilities of these resources in different ways. It implies that although students work in the same project-context, the practices of each group differ, and each individual implements the available possibilities in different but equally legitimate ways. Ravn (2008) exemplifies this in a concrete practice in a second semester project when he presents different group projects developed to show how these contribute to close the gap between formalism and application for a given scenario involving mathematics. For our purpose, we will present two of these projects:

> The first group studied the spread of bird flu in a concrete context in Denmark, which cannot be interpreted in mathematical terms without information from other scientific perspectives as for example biomedical aspects about the flu: its level of contagion, forms of treatment and their effectiveness. Students not only learned the mathematical content in solving a differential equation, but also how different constants in the mathematical equations critically affect the results in a complex application setting and reliability topics regarding the mathematical content.

> A second group studied a new technique of DNA-micro arrays for classification of certain illnesses. The students did some biological research to clarify the concept of a gene, visited the hospital where they had started to use the technique, and established a background for working with mathematical content such as different types of measures and cluster analyses. The students found that using different segments to measure or different types of cluster analyses produced divergent results on the same dataset. They learned that they must choose among several methodological options, depending on the problem to be solved.

In both cases the students had the opportunity to reflect upon the validity of a mathematical model and their connection with the context and empirical data. Thus, they learned mathematical theory in a real framework, and the practices in a concrete context helped them to see the complexity of doing mathematics and making decisions about appropriate theories or methodologies. For many engineering students this level of depth in the mathematical theory may not seem necessary. Rather than being able to apply the theory, they become competent in generating a *suitable knowledge assemblage* where mathematical language and tools, together with the tools from the other fields involved, provided ways of operating concretely in the contexts of their projects to respond to the problem guiding their investigation. The creation of suitable knowledge assemblages is a central competence as an engineer. In our perspective, these competences that students develop on the PO-PBL model are expressions of valid participation in concrete communities outside of the university.

For the Danish teachers it is clear that the competences gained, for example in relation to *suitable knowledge assemblage*, reach different levels in different semesters. However, upon graduation, it is expected that all students can use their experience to solve new problems outside the university. This can be interpreted as a transfer, and it is related to the idea of applying knowledge to new situations. Beach (1999) presents transfer as a problematic concept from a socio-cultural perspective of learning because transfer suggests that people carry knowledge and skills from one task or situation to another without the context, and assumes that the tasks across which transfer occurs remain unchanged during transference. These ideas about transfer do not consider that transformation across time and social situations is not a function of the individual or the situation, but rather of their relation. In this sense, generalization defined as continuity and transformation of knowledge, skill and identity across various forms of social organization, involves multiple interrelated processes rather than a single general procedure (Beach, 1999; Lobato, 2006). Van Oers (1998) provides a wonderful description of how generalization can be obtained by the embedding of context in other contexts:

> *This is called an activity of continuous progressive recontextualizing. The development toward more abstract forms of activities is one of the results of continuous progressive recontextualizing. On the basis of our observations, we have reason to assume that it is certainly not typically characterized by decontextualization*

> *or disembeddedness. Rather, the important thing was the possibility for the actors to create a new sign-based context related to their previous activities that made their new activity meaningful (p.141)*

We can observe the same process in the PO-PBL students: they engage in successive projects throughout their undergraduate studies with different disciplinary tasks and contexts. Part of the new semester is establishing a new group, and this implies negotiating the meaning of not only the new disciplinary content, but also of some competences as working in a group or managing a project. In the next project, each student has the possibility to recontextualize his/her previous activities and identities to engage in a completely new project and experience. In the long-term, the students learn to do a continuous progressive recontextualizing of their participation and become a full member with autonomous participation of this community. We can say that this flexibility in the participation is a powerful competence that will help new graduates an easy transition into the work environment.

CONCLUDING REMARKS

Let us conclude by revising our vision of learning. The underlying position is that higher competences are constituted in the routines, rituals, conventions and discourses exchanged with communities of specialists, and the purpose of studying a profession is to acquire mastery in these specialists' practice and competences that allow being a member of this community.

Looking at the PO-PBL Aalborg model from this perspective allows the integration of many of its principles and its theorization as a university practice. For example, the variability in the PO-PBL model is only one of the natural characteristics of these activity systems that explore and implement the possibilities of the resources in different ways. In this sense, the diversity of concrete practices offers a wider scope of possibilities to other institutions that may be interested in this model.

By analyzing the PO-PBL model in the faculty of sciences and engineering with a socio-cultural approach, we identified that working on their projects the students participate in practices that are closer to those of scientists and engineers by thinking about concrete and contextualized problems to which they intend to find a possible solution. In this way, the gap between the theory, tools and language, and their knowledge and participation in routines and ways of interaction of their discipline is smaller than in other university approaches.

What is most interesting in universities as institutions is that thinking of the ZDP as a space of symmetrical interaction between teachers and students that participate in these projects that are also new for teachers, they can learn not only pedagogical aspects but also about contextualization of their discipline or inter-disciplinary connections. This enables teachers to use their own competences not only in their research groups but also in their teaching time, which is a unique proposal in this field.

In this sense, there is an entire research line that deserves exploration, which could start by refining the theorization that we propose and continue with other dimensions like studies on how the participants interact in their groups during projects or the development of the role of teacher-supervisor in this model.

Finally, for other universities this analysis intended to identify the why's –beyond the how's – the PO-PBL model may be a source of inspiration for more enriching and innovative pedagogical proposals for both students and teachers. However, we are consequent with our position that there is no easy transference of the experience developed in Aalborg University to other institutions, but it is possible to re-contextualize the main ideas to look for possible practices that respond to the challenges and needs of these new contexts.

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Design, Implementation, and Evaluation of a Tutor Training for Problem Based Learning in Undergraduate Psychology Courses

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ABSTRACT

In this paper we describe a "Train the Tutor" programme (TtT) for developing the metacognitive skills, facilitator skills, and tutor skills of students in a problem based learning (PBL) context. The purpose of the programme was to train 2nd and 3rd year undergraduate students in psychology to become effective PBL tutors for "freshmen" (1st year psychology students). Based on the 3C3R concept of Hung (2006), various instructional problems have been designed and used in a 6 steps training programme. The programme has been evaluated both in a formative and summative approach through a quasi-experimental control group design with pre- and post-measurements before and after the training programme. The study was conducted as part of a curriculum re-design for promoting problem based learning in psychology courses for undergraduate students in a university of applied science. The results indicate the importance of metacognitive skills of the tutor for effectively facilitating the learning process in a PBL context.

Keywords: Problem based learning, tutor skills, metacognitive skills, tutor training, tutor effectiveness

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TUTOR COMPETENCIES IN A PBL LEARNING ENVIRONMENT

From our understanding, Problem-based Learning (PBL) is a group based learning approach, in which the learners engage themselves in research and problem solving activities in order to gain a deeper understanding of theoretical concepts and the practical relevance of the problem they want to solve. This learning process needs to be supported by tutors who monitor and "scaffold" the learning process through guidance, coaching and observation. They interfere and support the learners when these are stuck in the process or lose direction.

PBL tutors require a specific skill set and attitudes related to teaching and learning (Barrows, 1988; Smith & Cook, 2012). On the one hand, PBL tutors must stimulate the students to get involved in a collaborative learning process, on the other hand the tutor must ensure that the students articulate suitable learning objectives and follow a structured procedure while exploring the topic. This requires both excellent facilitator skills and metacognitive skills, i.e. the ability to observe and reflect the effectiveness of the learning process, the learning strategies applied, and the group dynamic within the tutorial group (Brown, 1978; Flavell, 1979; Kayashima & Inaba, 2011). Metacognitive skills need to be distinguished from cognitive skills (Veenmann, Van Hout-Wolters & Afflerbach, 2006). Cognitive skills refer to a person's declarative and procedural knowledge in a certain domain, while metacognitive skills refer to knowledge of problem solving strategies, the ability how to organize and structure learning activities, and the understanding and the application of appropriate and effective learning strategies (Brown & DeLoache, 1978; Veenman, 2005). Table 1 shows a list of relevant metacognitive skills for learning as described by Hattie (2009).

Table 1

Overview: Metacognitive skills in a learning context, definitions and examples (Hattie, 2009, p. 190)

Metacognitive skill	**Definition**	**Example**
Organizing and transforming learning	Overt or covert rearrangement of instructional materials to improve learning	Making an outline before writing a paper
Asserting self-consequences of learning	Student arrangement or imagination of rewards or punishment for success or failure	Putting off pleasurable events until work is completed
Using self-instruction	Self-verbalizing the steps to complete a given task	Verbalizing steps of calculation in solving a maths problem
Using self-evaluation	Setting standards and using them for self-judgment	Checking work completion before handing in to the evaluator
Goal-setting / planning	Setting of educational goals or planning sub-goals	Making a list of items to accomplish during studying a certain subject
	Planning for sequencing, timing, and completing activities related to those goals	

Self-monitoring	Observing and tracking one's own performance and outcomes, often recording them	Keeping records of study output
Develop task strategies	Analysing tasks and identifying specific, advantageous methods for learning	Creating mnemonics to remember facts
Imagery	Creating or recalling vivid mental images to assist learning	Imagining the emotional and behavioural consequences e. g. after having passed a difficult exam.

Effective PBL tutors "scaffold" the learning process in a way that guides the students without patronizing. (Smith & Cook, 2012). Through stimulating, probing, questioning, paraphrasing and providing feedback, the tutor stimulates the elaboration of the problem and directs the learning process rather than presenting the right answers to the problem at hand. Thus, the challenge for the tutor is how to steer and to guide the learners without lecturing or providing the students with predefined schemes or answers to the problem.

In addition to these more process oriented interventions, which focus on the way how the students' discussion in the tutorial is led and how the learning content is reflected upon, the tutor also needs to make sure that the students understand the content and the context of the problem they tackle.

The 3C3R model of Hung (2006) (Figure 1) provides a framework that depicts six elements of process and content/context orientation in an effective PBL tutorial. It describes three structural elements (content, context, and connection) and three process elements (researching, reasoning, and reflecting).

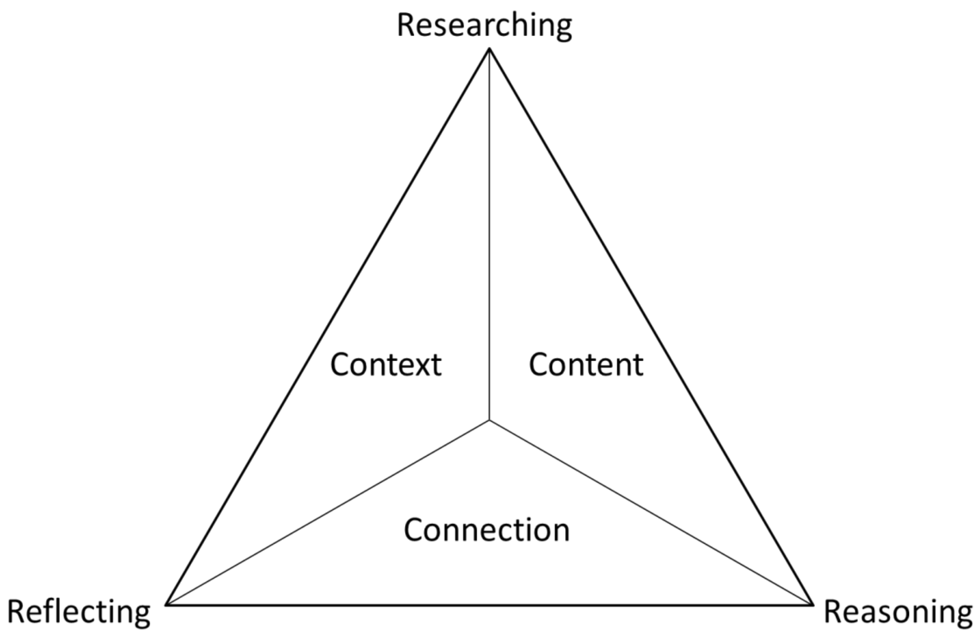

Figure 1.: 3C3R Framework for designing a problem space in a PBL learning environment (Hung, 2006)

Whereas “content” focuses on the scope and depth of the problem, “context” refers to the applicability to a specific field of practice, and “connection” represents the connection to other knowledge domains.
Considering relevant competencies of the tutor on the background of this framework, he or she should not only focus on *process* oriented questions that evoke *researching, reasoning* and *reflecting* among the students but he/she also needs to make sure that the *content*, *context*, as well as the *connections* with previous knowledge and related concepts are observed. Some researchers indicate that especially students with little or no experience need tutors with both high content oriented skills as well as process oriented skills (Davis, Nairn, Paine, Anderson & Oh, 1992; Dolmans, Gijselaer, Moust, De Grave, Wolfhagen & Van der Vleuten, 2002; Zumbach, 2011). Leary, Walker, Shelton & Fitt (2013) report in their recent meta-analysis of the relevance of tutor background, tutor training and student learning a meaningful and highly significant effect size (Hedge’s $g = 0.27$, $z = 6.75$, $p < 0.01$, $n = 223$) for content expertise of the tutor. However, PBL tutors with high expertise and content knowledge need to be aware of the danger to direct and constrain the learning too much, thus stalling the students’ self-regulated learning process (Silver & Wilkinson, 1991). Chng, Yew and Schmidt (2011) have investigated the effect of social congruence between tutor and students on achievement and learning. They suggest that the ability of the tutor to communicate informally with students and to create a positive learning climate that promotes a free flow exchange of ideas, has a greater impact on learning at each of the PBL phases as compared to the tutor’s subject-matter expertise and the ability to explain concepts in a way that is easily understood by students.

As a consequence the rationale for using peer facilitation in PBL with advanced students as tutors was based on the idea that through peer learning in small tutorial groups the students should be challenged by socially congruent peers to deeply reason, reflect and research the topic (3R) while the content, the context and the connection with the curriculum was fixed and provided by the faculty resp. the curriculum. A more practical reason for using peer students as PBL tutors in this particular case was the lack of qualified teaching resources that were sufficiently familiar with PBL methods and concepts. Hence, there was a strong need for an efficient and effective way to provide training for prospective PBL tutors as part of the new PBL curriculum.

Training Rationale and Design

Based on the recognized importance of metacognitive skills, facilitator skills, and tutor skills for effectively “scaffolding” the learning process of students, a training programme for prospective PBL tutors has been designed and evaluated in this study. The training programme was part of a wider curriculum transformation process for undergraduate psychology courses in a university of applied sciences. Problem based learning should become an integral element of the new curriculum, and developing a sufficient number of

qualified and certified PBL tutors was one of the critical contributing factors to the overall goal. One central design principle of the training was to use PBL as a core element for the training process itself. This means, the tutors were challenged to deal with ill-structured problems as they often arise during the tutorial process, such as observing and understanding group dynamics, dealing with students who try to get the "right" answers to the problem, or tutorial groups who are struggling with the definition of suitable learning goals, etc.
The underlying assumption here was that the PBL methods should be learned at best in a context that resembles the learning settings which the tutors should create later for their own students (Sockalingam & Schmidt, 2011).

Considering the role of the PBL tutor described in the previous section and acknowledging the relevant literature about the competencies needed by tutors to be effective, three major skill domains for tutor effectiveness have been identified (see also Barrows, 1988; Bertola & Murphy, 1994; Walsh, 2005):

1. *Metacognitive skills*, such as reflecting the current learning situation, understanding the impact of own behaviour on student learning, and knowing and applying a variety of learning strategies.

2. *Facilitator skills*, such as structuring the tutorial, creating a positive learning atmosphere, and leading through questioning and probing.

3. *Tutor skills*, such as stimulating the learning process, re-stating the learning objectives, re-phrasing relevant learning content, and stimulation the discussion and interaction in the tutorial group.

Hence, the main objectives of the "Train the Tutor" (TtT) programme have been defined as follows:

1. Develop *metacognitive skills* for facilitating collaborative learning processes based on PBL principles.

2. Learn *facilitator skills* for structuring the tutorial session (visualizing, summarizing, time keeping).

3. Learn how to use appropriate *tutor skills* in order to scaffold and stimulate the learning process in a tutorial group (elaborating, directing, integrating, and constructively interacting with each other).

The full "TtT" ("Train the Tutor") programme took four months altogether. It was divided into six modules (each of which took between 0.75 and 2 days) and time in-between for preparation, documentation and follow-up. The total time invest for the training participants was 150 hours (60 hours seminars/workshops, 90 hours for self-study, preparation, follow up). The programme was designed and facilitated by an experienced PBL practitioner and faculty member. Table 2 displays the structure and content of the training programme.

Table 2

Structure and content for the "Train the Tutor" (TtT) programme

Module No.	Duration	Training Objectives	Training Content
1	1.5 days (15 hours)	• Understand fundamentals of problem based learning (PBL) • Understand the role of the PBL tutor • Understand and practice basic facilitator skills	• History, goals and concepts of problem based learning • The role, the attitude, and the required competencies of PBL tutors • Basic facilitator skills (e. g. questioning, paraphrasing, stimulating, providing feedback)
Follow up and preparation for module 2 (4 weeks) (Time invest: approx. 5 hours / week)			
2	1.5 days (15 hours)	• Understand how to deal with ill-structured problems • Understand der 3C3R model and its application	• Characteristics of ill-structured problems • Content oriented and process oriented interventions (3C3R)
Follow up and design of a problem case for module 3 (4 weeks) (Time invest: approx. 5 hours / week)			
3	1.5 days (15 hours)	• Understand group dynamics in tutorial groups • Practice effective tutor interventions	• Stimulating the systematic elaboration of problems • Directing the learning process • Stimulating the integration of knowledge • Stimulating interaction and individual accountability
Follow up and preparation for module 4 (4 weeks) (Time invest: approx. 5 hours / week)			
4	1 day (6 hours)	• Learning from observing a role model	• Observing an experienced PBL tutor in action (plus briefing/debriefing)
Follow up and preparation for facilitating a PBL tutorial (4 weeks) (Time invest: approx. 5 hours / week)			
5	1 day (6 hours)	• Experience self-efficacy as a tutor • Practice acquired skills from modules 1 to 4	• Facilitate a PBL tutorial (plus observation and feedback by peers and master trainers)
Follow up and documentation (2 weeks) (Time invest: approx. 5 hours / week)			
6	1/2 day (3 hours)	• Common reflection of the training process and outcome	• Reflect metacognitive skills, facilitator skills, and tutor skills acquired through the training • Certification as a PBL tutor
Total: 150 hours in four months (60 hours seminars/workshops, 90 hours for self-study, preparation, follow up)			

EVALUATION OF THE TUTOR TRAINING PROGRAMME

The PBL tutor training programme has been evaluated both in a formative (during the training process) and summative way (at the end of the training process). The purpose of the formative evaluation was to modulate, test and adapt content, methods and process of the training procedure. In addition, the summative evaluation aimed at allowing for comparing the effectiveness of the training programme in comparison to another form of tutor instruction and a control group.
The major research question addressed in this evaluation study was:

To which extent can the PBL training for tutors support the development of metacognitive skills, facilitator skills, and tutor skills of the training participants, compared to other forms of instruction (control group 1) and no formal training or instruction (control group 2)?

In order to investigate this, a quasi-experimental research setting with repeated measures has been designed (Factor A: training group vs. control groups 1 and 2; Factor B: pre-measure and post-measure vs. post measure only). Factor A varies the intensity of training and instruction (1: PBL tutor training, 2: instruction through reading a tutor manual and guide, 3: no formal training or instruction), whereas factor B controls the influence of the pre-test on the post-test (1: pre- and post-test, 2: post-test only). The resulting evaluation design with the sample size of each cell is represented in table 3.

Table 3

Research Design: Factor A (Training group, Control groups 1 and 2), Factor B (pre- and post-test vs. post-test only)

		Factor B	
		B_1: pre-test and post-test	**B_2: without pre-test (post-test only)**
Factor A	**A_1: Training group**	Training group (A_1 B_1) (*n*=21)	Training group (A_1 B_2) (n=17)
	A_2: Control group 1	Reading the "McMaster PBL tutor guide" (Walsh, 2005) (A_2 B_1) (*n*=19)	Reading the "McMaster PBL tutor guide" (Walsh, 2005) (A_2 B_2) (n=21)
	A_3: Control group 2	No formal training or instruction (A_3 B_1) (*n*=20)	No formal training or instruction (A_3 B_2) (*n*=20)

Participants

119 individuals (undergraduate psychology students in their second and third year and master students in their first year) participated in the evaluation study. All participants had completed fundamental modules in psychology before at least with satisfactory marks. The participants in the training group had been selected based on academic credits, and personal interest/motivation for facilitating PBL tutorials immediately after completion of the six modules. The remaining participants were assigned to the control groups in order to be trained later. Figure 2 displays a flow diagram which describes how the participants were streamed to the various cells in the quasi-experimental research setup.

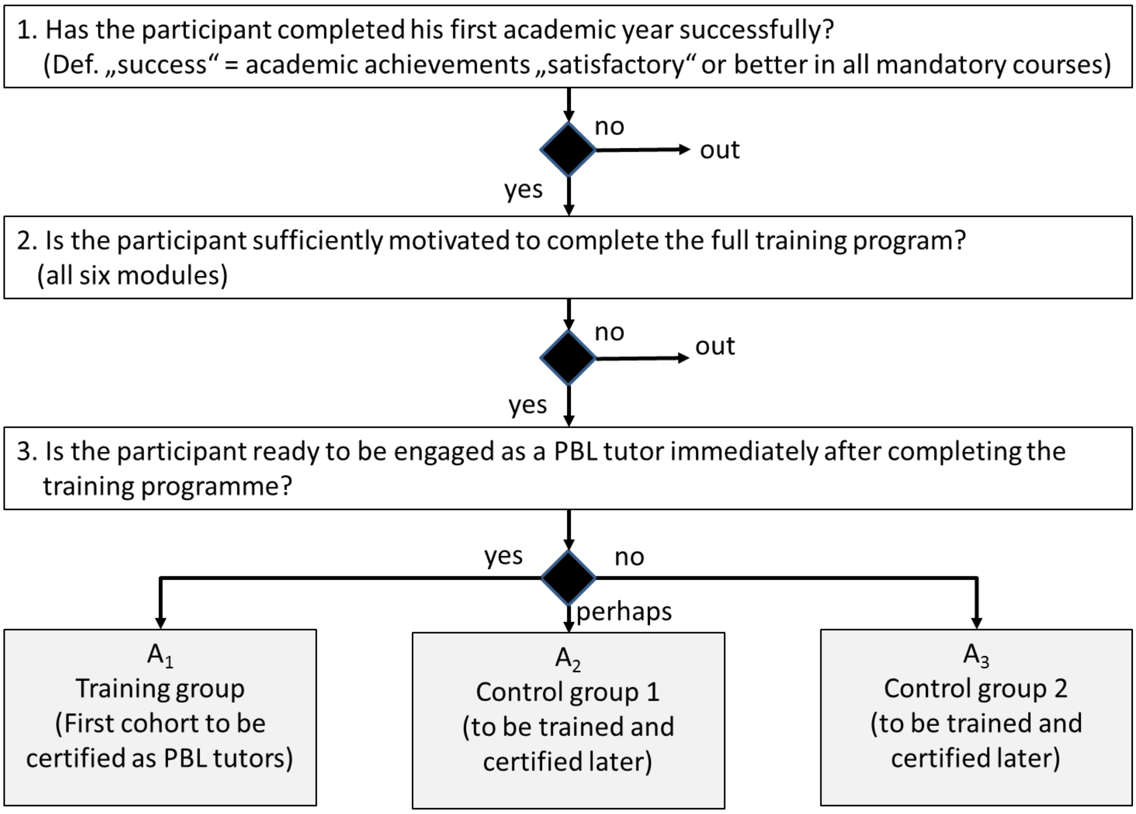

Figure 2. Flow diagram for visualizing the streaming of participants to the training group, control group 1 and control group 2 (own source)

Even though this controlled and selective allocation of participants to the training group and the control groups limits the internal validity of the research design, we decided not to push back participants who were interested in the training in favour of other students who were not available to be actively engaged in the fast deployment of the PBL curriculum. Later we will discuss the consequences of this decision regarding the validity and generalizability of the results.

The participants' average age was 22.2 years (SD = 4.2). 28 (25%) subjects were male, 85 (75%) were female, which is a usual gender distribution in psychology undergraduate courses in Germany. 43 (38%) of the sample participants had previous experience as a learning facilitator e.g. in junior school or as trainers in youth sports clubs. 52 (46%) explained their interest to be engaged as a PBL tutor in the psychology study programme for undergraduates immediately after completion of the training programme or later.

Tutorials

The tutorials were part of an undergraduate course (1st year) in personality psychology. These tutorials (90 min.) were accompanied by lectures once per week (90 min.). Based on the content of the lectures the students were assigned to discuss a specific problem or case thereafter and to formulate some learning goals as a preparation for the next lecture. This case was designed in such a way that it stated an ill-structured problem and triggered the discussion of the students related to the relevant concepts introduced in the lecture. Each tutorial group consisted of 10 to 12 students and was facilitated by a PBL tutor. Attending the tutorial was not mandatory for the students, however highly recommended by the faculty. On average, each group had one tutorial per week. Four to five tutorials ran in parallel.

Measures

The measures combined different sources of information by utilizing self-report measures of the tutor, behavioural measures of tutor effectiveness, as well as student satisfaction measures. Through this multi-method approach, a broader investigation into the effectiveness of the tutor training on metacognition, behaviour, and tutor effectiveness should be achieved.

Tutor Skills Self-report (Questionnaire)

In order to create a reliable and valid measure for self-perceived tutor skills, a questionnaire (28 items) with four scales has been designed. Each scale consisted of 7 items (see annex 1).

1) MCSL (Meta-cognitive skills related to guiding learning groups) (e.g. "I have a large variety of behavioural strategies how to steer group dynamics.")

2) MCSR (Meta-cognitive skills related to self-regulation) (e.g. "I have a clear mental model of how to plan, do, and check my actions and their behavioural and emotional effects.")

3) FAS (Facilitator skills) (e.g. "I can easily structure group discussions.")

4) TUT (Tutor skills) (e.g. "I can easily evaluate different levels of knowledge and subject matter understanding of students in a tutorial group.")

The psychometric analysis of the questionnaire revealed sufficient internal consistencies for all four scales (Cronbach'sα: .69 - .78). Each item had to be rated by the subjects on a 5 points Likert scale (1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree).

The sum of the scales was used as a measure for the self-reported metacognitive skills related to guiding learning groups (MCSL), self-regulation (MCSR), facilitator skills (FAS) and tutor skills (TUT).

TIP (Tutor Intervention Profile)

The "Tutor Intervention Profile" (TIP) is a behaviour observation method and manual developed at the University of Maastricht (The Netherlands) in order to evaluate tutor behaviour effectiveness (De Grave, Dolmans & Van der Vleuten, 1998, 1999). It has been tested for reliability and validity and has been used as a method for tutor assessment in many cases. TIP encompasses four behavioural dimensions of tutor competencies regarding learning process-oriented interventions: (1) Stimulating elaboration, (2) Directing the learning process, (3) Stimulating the integration of knowledge, and (4) Stimulating interaction and individual accountability of the students.

Table 4 displays the four behavioural dimensions for tutor effectiveness of the TIP and shows two example items for each dimension.

Table 4

Dimensions of the Tutor Intervention Profile (TIP) (De Grave, Dolmans & Van der Vleuten, 1998)

Dimension	**Example**
1. Stimulating elaboration (SE)	• … stimulates a more in-depth brainstorm by, for example, asking questions, asking for clarification, and stimulating relations. • …stimulates the identification of gaps in students´ prior knowledge.
2. Directing the learning process (DLP)	• … stimulates generating learning issues with sufficient depth and width. • … draws the attention of students to gaps in prior knowledge while generating learning issues.
3. Stimulation the integration of knowledge (SI)	• … stimulates the integration on new acquired knowledge with knowledge acquired with previous cases. • … stimulates the students to apply the knowledge gained during self-study to explain the phenomena described in the case.
4. Stimulating interaction and individual accountability (SIINDACC)	• … stimulates students to make an inventory of the learning resources consulted during self-study. • … stimulates students to report out in their own words rather than reading from notes or photocopies.

14 PBL tutors, who had completed the training programme before, have been assessed through peers and trainers, who observed the interaction between the tutor and the students

during the tutorial on a five point scale (0: not effective, 1: fairly effective, 2: moderately effective, 3: effective 4: highly effective).

Learner Satisfaction Measures (Questionnaire).

As a third measurement, the students who participated in the PBL tutorials rated the effectiveness of the tutor at the end of the tutorial on three items (see annex 2):

1. Satisfaction with the learning outcome (SLO). This measure indicates overall student satisfaction with the learning outcome of the tutorial, directly at the end of the tutorial.

2. Satisfaction with the learning process (SLP). This measure indicates the satisfaction with the learning process (pace and structure).

3. Satisfaction with the learning content (SLC). This measure indicates the satisfaction with the relevance, depth and width of the learning content.

Each student rated his or her level of satisfaction at the end of the tutorial on a 5 points Likert scale ("0" representing total dissatisfaction, "4" representing maximum satisfaction).

Procedure

The training group (n=38) followed the training programme as described in table 3. Control group 1 (n=40) was instructed to read the PBL tutor guide of the McMaster University in Hamilton, Canada, which is available online (Walsch, 2005). The rationale behind this was to test whether the resources invested in designing and implementing the PBL tutor training programme was justified in comparison with less expensive and less time consuming methods for preparing and instructing novices as PBL tutors. Control group 2 (n=41) did not receive any instruction or training. All subjects were pulled from the same population of undergraduate psychology students. The training group was selected based on personal interest and academic credits (see "participants" section). Control groups 1 and 2 were compiled randomly. Half of the subjects completed the tutor skills self-report (questionnaire) before the start of the training programme and at the end. The other half completed the questionnaire at the end of the programme only. The aim of this procedure was to control if the pre-test had an effect on the post-test. Only those who actually completed at least steps 1 to 4 of the training programme were eligible as PBL tutors. Out of these, 14 tutors have been evaluated by peers and master trainer through observation and assessment with the TIP (Tutor Intervention Profile) and student assessment (see "measures"). Academic achievements, earlier experience as tutors in secondary school or clubs and motivation to become actively engaged as a PBL were recorded as control variables.

Research Hypotheses

The following hypotheses should be tested in this quasi-experimental study.

Hypothesis 1: The PBL tutor training should have significant positive effects on the facilitator skills, tutor intervention skills, and metacognitive skills of the training participants compared to the control groups 1 and 2.

Hypothesis 2: The pre-test should have no effect on the post-test results for self-reported tutor skills.

Hypothesis 3: Metacognitive skills, facilitator skills and tutor skills should be positively correlated with student satisfaction measures.

Hypothesis 4: Self-reported tutor skills (questionnaire data) should be positively correlated with effective tutor behaviour as measured by the TIP (Tutor Intervention Profile).

RESULTS

Table 5 shows the correlations for all measures: Tutor skills self-report (questionnaire), observation of tutor behaviour with tutor intervention profile (TIP), and student satisfaction at the end of the tutorial.

Table 5

Inter-correlations of all measures (Correlation Coefficient: Spearman-Rho)

		M (total)	SD (total)	MCSL (pre-test)	MCSL (post-test)	MCSR (pre-test)	MCSR (post-test)	FAS (pre-test)	FAS (post-test)	TUT (pre-test)	TUT (post-test)	SE	DLP	SI	SIINDACC	SLO	SLP	SLC
Tutor skills self-report (1)	MCSL (pre-test)	24.1	3.3															
	MCSL (post-test)	25.1	3.7	.42 * (n=33)														
	MCSR (pre-test)	26.8	3.1	.33 * (n=53)	.30 (n=34)													
	MCSR (post-test)	27.4	4.0	.17 (n =35)	.60 ** (n=36)	.54 ** (n=36)												
	FAS (pre-test)	25.8	3.3	.53 ** (n=49)	.18 (n=31)	.48 ** (n=50)	.33 (n=33)											
	FAS (post-test)	26.8	3.6	.33 (n=34)	.65 ** (n=33)	.19 (n=35)	.58 ** (n=35)	.53 ** (n=32)										
	TUT (pre-test)	24.1	3.0	.34 * (n=53)	.07 (n=34)	.21 (n=54)	.09 (n=36)	.54 ** (n=50)	.28 (n=35)									
	TUT (post-test)	24.2	4.0	.26 (n=35)	.61 ** (n=34)	.11 (n=36)	.40 ** (n=35)	.40 * (n=33)	.67 ** (n=35)	.40 * (n=36)								
Tutor intervention profile (TIP)	SE (2)	3.3	1.0		.68 * (n=14)		.43 (n=14)		.76 ** (n=14)		.70 ** (n=14)							
	DLP (2)	3.6	1.0		.73 ** (n=14)		.38 (n=14)		.71 ** (n=14)		.74 ** (n=14)	.55 * (n=14)						
	SI (2)	3.0	0.8		.61 * (n=14)		.20 (n=14)		.53 * (n=14)		.63 * (n=14)	.64 * (n=14)	.58 * (n=14)					
	SIINDACC (2)	2.3	1.0		.66 * (n=14)		.26 (n=14)		.56 * (n=14)		.67 * (n=14)	.73 ** (n=14)	.69 * (n=14)	.55 * (n=14)				
satisfaction measures	SLO (2)	3.0	0.6		.59 * (n=14)		.52 (n=14)		.66 * (n=14)		.44 (n=14)							
	SLP (2)	3.1	0.7		.01 (n=14)		-.08 (n=14)		.26 (n=14)		-.13 (n=14)					.63 * (n=14)		
	SLC (2)	2.8	0.4		.38 (n=14)		.20 (n=14)		.55 * (n=14)		.27 (n=14)					.65 * (n=14)	.66 ** (n=14)	

Notes:

(1) n is varying in the different cells due to missing values in the data; n is generally smaller than total sample size due to drop out and missing data.

(2) n = 14 (data only for training group available, control groups have not been evaluated as PBL tutors). * Correlation statistically significant ($p < .05$, two-tailed) ** Correlation statistically significant ($p < .01$, two-tailed)

MCSL: Metacognitive skills related to guiding learning groups, MCSR: Metacognitive skills related to self-regulation, FAS: Facilitator skills, TUT: Tutor skills, SE: Stimulating elaboration, DLP: Directing the learning process, SI: Stimulating the integration of knowledge, SINDACC: Stimulating interaction and individual accountability, SLO: Satisfaction with the learning outcome, SLP: Satisfaction with the learning process, SLC: Satisfaction with the learning content

The self-reported measures for metacognitive skills (MCSR, MSCL), facilitator skills (FAS) and tutor skills (TUT) are highly correlated. There are also strong correlations between the self-report (questionnaire) and the TIP ratings (observer ratings). Moreover, high correlations between student satisfaction measures (SLO, SLP, SLC) and self-reported facilitator and tutor skills are high. However, this holds true only regarding satisfaction with the learning outcome (SLO), not so much for satisfaction with the learning process (SLP) and the learning content (SLC).

The training group had higher scores on all four scales in the post-test compared to the pre-test (see Figure 3). The control groups had partly higher and lower scores. On the TUT scale there was even a drop between pre-test and post-test for control group 1.

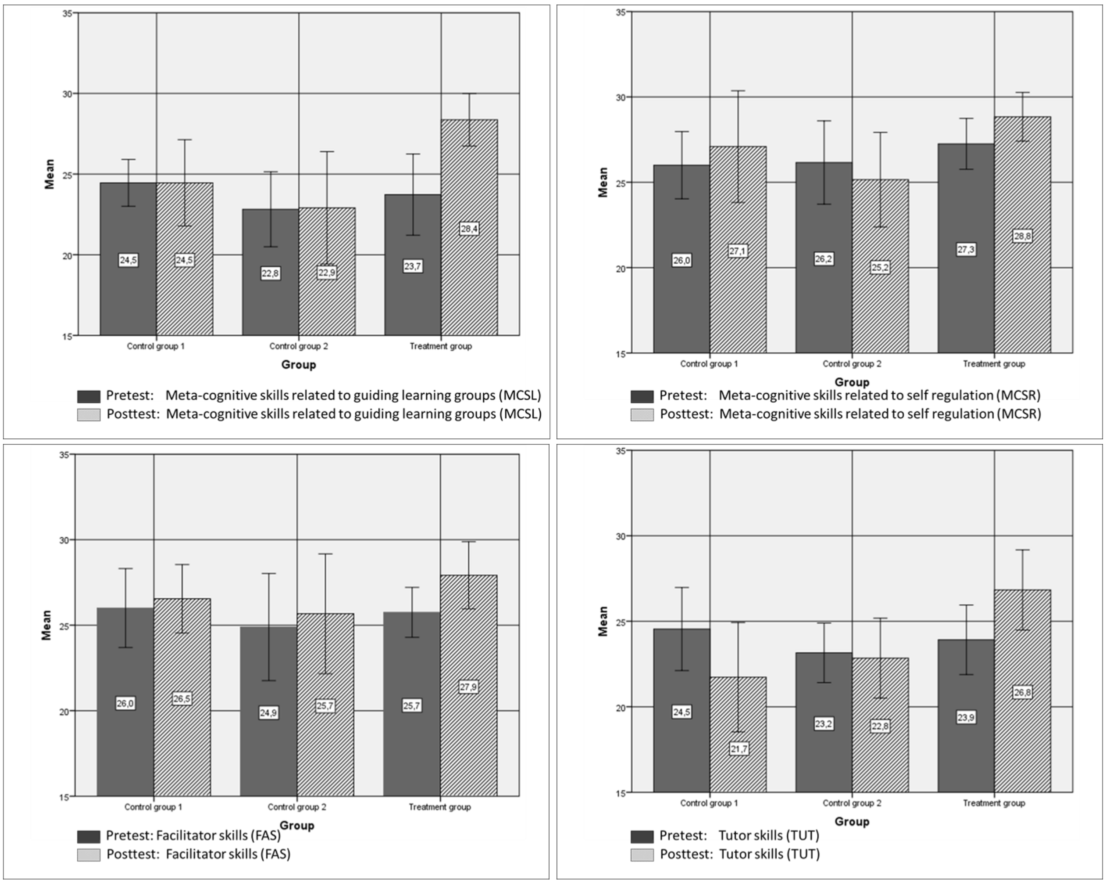

Figure 3. Tutor skills self-report (pre-test, post-test) (standardized scale values for MCSL (Metacognitive skills related to guiding learning groups) MCSR (Metacognitive skills related to self-regulation), FAS (Facilitator skills) and TUT (Tutor skills)

Applying a MANOVA procedure with factors A (training vs. reading the tutor guide vs. no formal training and instruction) and B (pre- and post-test vs. post-test only) for the four dependent variables MCSL, MCSR, FAS, and TUT showed a highly significant effect for factor A, no effect for factor B, and a highly significant interaction between factors A and B for the dependent variable MCSL (Table 6).

Table 6

Multivariate Analysis of Variance (MANOVA) – Statistics for dependent variables MCSL (Metacognitive skills related to guiding learning groups), MCSR (Metacognitive skills related to self-regulation), FAS (Facilitator skills), TUT (Tutor skills)

Source of Variation	Dependent Variables	Sum of Squares (Type III)	Df	Mean of Squares	F	Sig.	Partial Eta^2
Adjusted model	MCSL	305.40[a]	5	61.08	5.75	.000 **	.213[a]
	MCSR	160.91[b]	5	32.18	2.22	.058	.095[b]
	FAS	146.49[c]	5	29.30	2.81	.020 *	.117[c]
	TUT	300.62[d]	5	60.12	4.48	.001 **	.175[d]
Constant term c	MCSL	67807.27	1	67807.27	6384.08	.000	.984
	MCSR	81695.18	1	81695.18	5631.16	.000	.982
	FAS	78002.21	1	78002.21	7466.72	.000	.986
	TUT	63794.01	1	63794.01	4757.66	.000	.978
Factor A (training group vs. control group 1 vs. control group 2)	MCSL	156.25	2	78.13	7.36	.001 **	.122
	MCSR	113.62	2	56.81	3.92	.023 *	.069
	FAS	131.52	2	65.76	6.30	.003 **	.106
	TUT	199.15	2	99.58	7.43	.001 **	.123
Factor B (pre- and post-test vs. post-test only)	MCSL	7.24	1	7.24	.68	.411	.006
	MCSR	34.55	1	34.55	2.38	.126	.022
	FAS	16.73	1	16.73	1.60	.208	.015
	TUT	20.20	1	20.20	1.52	.222	.014
Interaction (Factor A * Factor B)	MCSL	146.09	2	73.04	6.88	.002 **	.115
	MCSR	36.58	2	18.29	1.26	.288	.023
	FAS	4.26	2	2.13	.20	.816	.004
	TUT	75.64	2	37.82	2.82	.064	.051
Error	MCSL	1125.86	106	10.62			
	MCSR	1537.82	106	14.51			
	FAS	1107.34	106	10.45			
	TUT	1421.32	106	13.41			
Total variation	MCSL	71631.40	112				
	MCSR	85877.03	112				
	FAS	81396.83	112				
	TUT	67342.67	112				
Adjusted total variation	MCSL	1431.26	111				

	MCSR	1698.72	111
	FAS	1253.83	111
	TUT	1721.94	111

a. R^2 = .213 (adjusted R^2 = .176)
b. R^2 = .095 (adjusted R^2 = .052)
c. R^2 = .117 (adjusted R^2 = .075)
d. R^2 = ,175 (adjusted R^2 = ,136)

* F value statistically significant ($p < .05$, two-tailed) ** F value statistically significant ($p <.01$, two-tailed)

The effect size for the training group between pre- and post-test was largest for metacognitive skills of the tutor related to guiding learning groups (MCSL). Smaller effects could be observed for metacognitive skills of the tutor related to self-regulation (MCSR), facilitator skills (FAS), and tutor skills (TUT) (Table 7).

Table 7

Effect sizes (Cohen's d) for the training group with pre- and post-test (n=21)

	***M* pre-test**	***M* post-test**	***SD* pre-test**	***SD* post-test**	**Cohen's d**
MCSL	23.7	28.4	5.67	5.76	0.84
MCSR	27.3	28.8	6.86	5.66	0.24
FAS	25.7	27.9	10.50	9.61	0.22
TUT	23.9	26.8	8.18	13.69	0.27

MCSL: Metacognitive skills related to guiding learning groups, MCSR: Metacognitive skills related to self-regulation, FAS: Facilitator skills, TUT: Tutor skills

CONCLUSIONS

The data indicate and support the effectiveness of the training programme for pbl tutors for developing metacognitive skills related to guiding and steering learning groups in a pbl tutorial. However, there were only small effects for the development of facilitator skills and tutor skills. We conclude from our date that the training should include more exercises for building these skills in the future. It also needs to be considered that the newly trained and certified PBL tutors have completed the questionnaire right at the end of the training programme. Many of them have had no or very limited experience with facilitating tutorials outside the training programme. In follow-up measures we need to evaluate the mid-term and long-term effects of the training programme on tutor effectiveness.

There are strong correlations between self-reported metacognitive skills related to guiding learning groups and self-regulation on the one side, and both facilitator and tutor skills on the other side. This supports the conclusion that a PBL tutor training programme should not only cover the technical aspects of problem based learning (e. g. instructing, stimulating, probing questions, elaborating) but also support the development of reasoning and reflection skills as described in the 3C3R framework of Hung (2006).

Our study demonstrates the added value of intensive training for prospective PBL tutors compared with other methods, e.g. self-study of a PBL tutor guide only without complementary training, coaching or advice. This does not conclude that the available tutor guides are not helpful or supportive. However, self-study of these training materials might not be enough to develop the critical metacognitive and behavioural skills in order to achieve best performance as a PBL tutor.

SUMMARY, DISCUSSION AND OUTLOOK

Overall, the "Train the Tutor" Programme has shown satisfactory effects on the development of metacognitive skills related to guiding learning groups (*Effect size (Cohen's d) = .84)*. The effects for other dependent variables (MCSR; FAS, TUT) was still measurable, but smaller (*Effect sizes (Cohen's d) = .22 - .27).* In order to reach a stronger effect size for metacognitive-skills related to self-regulation and facilitator skills the training needs to be modified and should include more specific exercises for developing these competencies in particular.

For example, the training participants could be challenged more with difficult group situations (e. g. low participation, active or passive resistance of the group members to tutor interventions), in which they need to reflect first how these negative stimuli affect their self-regulation (cognitive, emotion, motivation) and then choose and execute appropriate interventions. This conclusion is supported by the low score on the item "I have no problems to deal effectively with "difficult" participants in a group setting (e. g. very dominating people)." (Mean = 3.62; SD = .91) (ANNEX 1). In comparison, the overall self-assessment after the training through the participants was higher on facilitation skills (Mean = 26.81; SD = 3.55) rather than tutor skills (Mean = 24.24; SD = 4.03) (ANNEX 1). This indicates that in the next run the training needs to be adjusted in a way that intensifies PBL tutor skills as described in the Tutor Intervention Profile (TIP).

In addition, the prospective tutors should be trained better how to construct appropriate and challenging problems for themselves before presenting problems to others. This is concluded from the comparably low score and part-whole correlation of the item "I find it easy to design

PBL cases for students to share, discuss, and learn.” (Mean = 3.07; SD = .98; r_{tt} = .27) (ANNEX 1). One way of doing this is the opportunity to assign the training participants to define and describe task-related problems and let them work through the process. Later they should reflect their learning process and report back to others about their observations and key learning points. More than that, the empirical data supports the importance of active learning and group based learning for an effective PBL “Train the Tutor” (TtT) process compared to self-study (control group 1) or no training at all (control group 2).

The pre-test vs. pre-/post-test condition had no effect on the post-test results for self-reported tutor skills; except, there was a strong interaction effect between the factors A (training group vs. control groups) and B (pre-/post-test vs. post-test only) for the dependent variable MCSL. The subjects who had completed the pre-test before and took part in the training had the highest scores on this scale. This indicates the possibility that the awareness of the items in the pre-test has focussed and primed the training participants with pre-test experience more than those in the post-test condition only.

Metacognitive skills of PBL tutors were positively correlated with student satisfaction measures for the learning outcome, not so much with the learning content or the learning process. Facilitator skills were positively correlated with both student satisfaction with the learning outcome and content.

More experimental and better controlled studies should investigate the cognitive, affective and behavioural mechanisms of effective PBL tutorials in detail. Especially the quality of the relationship between the tutor and the students might be relevant for both student satisfaction and the learning outcome. This conclusion is supported by other research results which describe that the development of effective tutor behaviour is an effective way to improve the learning process and achievement of the students in a PBL curriculum (Chng, Yew & Schmidt, 2011; Schmidt & Moust, 2000, Wetzel, 1996).

Another way for elaborating this study further could be to videotape the interaction between tutor and students and to interview the tutor later while showing him/her the video. He/she then might verbalize his observations, intentions and metacognitive strategies during the various phases of the tutorial.

Problem based learning has a lot of potential for improving the learning effectiveness of self-regulated learning groups in secondary and higher education (Azer, 2008; Weber, 2004). Well trained and capable tutors play a crucial role in this setting. The more we want to shift from teaching to learning in the curricula the higher becomes the importance of creating supporting organizational structures for learning and development. Developing and training a sufficient number of effective PBL tutors is one critical element of such a learning architecture.

LIMITATIONS

The data gathered in this study are limited in terms of reliability. While the questionnaire for self-reported tutor skills shows acceptable though not excellent values of internal consistency (Cronbach's α 0.69 – 0.78), the reliability of the TIP data can be challenged due to the limited number of observations and observers (n=14). There is also a lack of qualitative data, e.g. from interviews with participants before, during, and after completion of the training programme. In an improved "mixed methods" design, the combination of qualitative with quantitative data should be pre-considered in order to cross-validate the data. Due to these limitations it cannot be clarified definitely how large the effect size of the training programme on the dependent variables really was, and to which extend other factors like maturation over time or the self-selection of training participants have influenced the observed behaviours of the PBL tutors and their effectiveness.

The strong inter-correlations of the four scales of the questionnaire (MCSL, MCSR, FAS, TUT) indicate a strong common factor underlying the data structure. A confirmatory factor analysis of the data has shown a rather inconsistent image. More research is needed to increase the psychometric quality of the questionnaire applied in this exploratory study.

The non-randomized allocation of participants to the training group has limited both the internal validity and the generalizability of our conclusions. Therefor it is necessary to repeat this study in a more controlled experimental setting with completely randomized groups in order to test potential effects of selection or self-selection of training participants on the results.

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ANNEX 1
Questionnaire for measuring self-reported meta-cognitive skills, facilitator skills, and tutor skills

1) MCSL (Meta-cognitive skills related to guiding learning groups)

Item No.	Item	Mean	SD	r_{tt}	Cronbach's α if item deleted
1	I have a large variety of behavioural strategies how to steer group dynamics.	3.50	.78	.47	.67
2	I know how to deal with difficult situations in group settings (e, g, interpersonal conflicts).	3.70	.77	.41	.69
3	Before engaging in a group situation I have plan what to do in order to reach the (learning) goals of the tutorial.	3.53	.85	.59	.64
4	I can judge in advance how a tutorial group will react to my questions, guidance, and interventions. (*)	3.47	.86	.27	.72
5	I can easily reflect and understand the reasons when a tutorial group is not collaborating effectively.	3.85	.90	.44	.67
6	I find it easy to integrate different types of people in the collaborative learning process.	3.53	.98	.44	.68
7	I know how to evaluate the effectiveness of the collaborative learning process in a tutorial.	3.51	.88	.37	.70

(*) item deleted due to unsatisfactory r_{tt} and higher Cronbach's α if item deleted
Scale statistics

Sample size (valid cases): n = 90	Number of items: 7	Mean: 25.11	Min: 17	Max: 34	SD: 3.66	Cronbach's α for standardized items: .72

2) MCSR (Meta-cognitive skills related to self-regulation)

Item No.	Item	Mean	SD	r_{tt}	Cronbach's α if item deleted
1	I can easily judge alternatives for my actions at any time.	3.80	.74	.53	.69
2	Especially in stressful situations I can verbalize my feelings and emotions very well.	3.69	1.05	.39	.71
3	I have a clear mental model of how to plan, do, and check my actions and their behavioural and emotional effects.	3.85	.87	.33	.72
4	I am able to think through various alternatives for action paths and evaluate their consequences.	3.79	.90	.49	.69
5	I am aware of my emotions when doing things.	4.14	.98	.51	.68
6	I reflect my actions regularly and ask others for feedback.	3.78	.96	.39	.71
7	If I do not know the answer to a problem I am able to admit that, and I know whom to address to for support.	4.34	.86	.50	.69

Scale statistics

Sample size (valid cases): n = 94	Number of items: 7	Mean: 27.39	Min: 16	Max: 35	SD: 3.95	Cronbach's α for standardized items: .74

3) FAS (Facilitator skills)

Item No.	Item	Mean	SD	r_{tt}	Cronbach's α if item deleted
1	I am good at active listening.	4.38	.82	.53	.61
2	I can easily structure group discussions.	3.65	.82	.38	.65
3	I am able to summarize the results of group discussions.	3.84	.88	.43	.64
4	I am able to visualise ideas and concepts on a white board or flip chart.	3.68	.97	.32	.67
5	I have no problems to deal effectively with "difficult" participants in a group setting (e. g. very dominating people).	3.62	.91	.40	.65
6	I am able to manage and keep the time in group settings.	3.66	.83	.31	.67
7	I keep friendly and treat everyone respectfully, especially in difficult group situations.	3.98	.80	.39	.65

Scale statistics

Sample size (valid cases): n = 92	Number of items: 7	Mean: 26.81	Min: 15	Max: 34	SD: 3.55	Cronbach's α for standardized items: .69

4) TUT (Tutor skills)

Item No.	Item	Mean	SD	r_{tt}	Cronbach's α if item deleted
1	I find it easy to design PBL cases for students to share, discuss, and learn. (*)	3.07	.98	.27	.80 (*)
2	I can easily evaluate different levels of knowledge and subject matter understanding of students in a tutorial group.	3.34	.85	.54	.74
3	I can easily integrate people with different learning skills in a learning group.	3.37	.86	.50	.75
4	I have always an idea how I can support a learning group that is struggling with a task.	3.16	.85	.62	.73
5	I am able to create a positive atmosphere and learning climate in a group.	3.74	.93	.64	.72
6	I am able to stimulate interaction and individual accountability in a learning group.	3.57	.78	.54	.74
7	I find it easy to provide feedback to a group regarding the effectiveness of their learning process.	3.98	.90	.45	.76

(*) item deleted due to unsatisfactory r_{tt} and higher Cronbach's α if item deleted

Scale statistics

Sample size (valid cases): n = 94	Number of items: 7	Mean: 24.24	Min: 12	Max: 33	SD: 4.03	Cronbach's α for standardized items: .78

ANNEX 2

Questionnaire for measuring the satisfaction of students at the end of the tutorial

1) SLO (Satisfaction with the learning outcome)

Item No.	Item	0 very dissatisfied	1 dissatisfied	2 neutral	3 satisfied	4 very satisfied	Mean	SD
1	Overall, I am satisfied with the learning outcome of this tutorial.						3.0	0.6

2) SLP (Satisfaction with the learning process)

Item No.	Item	0 very dissatisfied	1 dissatisfied	2 neutral	3 satisfied	4 very satisfied	Mean	SD
1	Overall, I am satisfied with the learning process of this tutorial regarding pace and structure.						3.1	0.7

3) SLC (Satisfaction with the learning content)

Item No.	Item	0 very dissatisfied	1 dissatisfied	2 neutral	3 satisfied	4 very satisfied	Mean	SD
1	Overall, I am satisfied with the learning content of this tutorial.						2.8	0.4

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Students' Attitudes Towards Group-based Project Exams in Two Engineering Programmes

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ABSTRACT

At Aalborg University, engineering students spend half the time each semester in groups working on projects in a problem-based learning (PBL) curriculum. The projects are assessed through group exams, except for between 2007 and 2013 when the law forbade group-based project exams. Prior to 2007, a survey showed that students preferred the group-based project exams and a new study was consequently conducted after the 2013 reintroduction of group exams. Again, the results demonstrated that students prefer the group exam, but that there are significant differences between students from various engineering programmes. We compare the two programmes "Architecture and Design" and "Software Engineering", and find that students in the latter programme feel more positively towards the group exam. A further result is that one-third of the students testified that facing a new type of exam did not affect their behaviour at all. This might suggest that the "backwash" effect of an exam on student behaviour is not as present in these students as is often expected and argued in education research. We also argue that what the students' base their views upon forms part of the informal or experienced curriculum, which is not necessarily equal to the formal curriculum.

INTRODUCTION

At Aalborg University (AAU) in Denmark, problem-based project work is quite extensive, and in the engineering programmes students spend half the study time each semester working in groups consisting of three to eight students on projects in a problem- and project-based learning curriculum (PBL). A PBL curriculum is characterized by students working in teams on projects involving several steps from problem analysis, through problem solving to

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metacognition (de Graaff & Kolmos, 2007). Although Kolmos, Holgaard and Dahl (2013) conclude that there is not *one* dominant Aalborg PBL model, the education at AAU is in general organized based on shared PBL principles (Barge, 2010), which are: Problem orientation, Project organization, Integration of theory and practice, Participant direction, Team-based approach, and Collaboration and feedback.

At AAU, the projects are assessed through oral group-based project exams, usually lasting around four hours for a student group of six. The project exam consists of three phases: first, a group presentation of the project; second, a group discussion phase in which an external examiner and the supervisor examine the group through questions and in which the students may comment on each other's answers; and finally, a third phase where students must answer questions individually. Each student then receives an individual mark that may or may not be the same mark as the other group members.

From 2006 to 2012, the Danish government banned the use of group-based project exams across the whole education sector. However, the PBL curriculum did continue with student groups working on PBL projects during the semesters, and with a replacement of the group-based project exams with individual oral exams of around half-an-hour's length per student. This situation gave rise to a number of research studies on assessment methods in a PBL curriculum, such as the one at AAU. These studies in particular focused on the students' and staff's attitudes towards and experiences of two very different types of assessment: individual exams and group-based exams of project learning.

The focus on attitudes and experiences was on the one hand based on the assumption that a change of the exam format would create a misalignment in the formal curriculum, but the real driving force for a change away from a PBL curriculum would be based on the stakeholder's opinions and cultural practices. As was seen in many academic institutions, student-centred learning practices were under constant pressure from disciplines to be more at the core of the curriculum – and at AAU, this was also an underlying tension in the curriculum, which could easily become stronger , if assessment were changed. So the intention with the first studies was to study the attitudes and experiences as an element in this top-down change.

However, some of the early studies (Holgaard, Kolmos and Du, 2007; Kolmos & Holgaard, 2007) concluded that the students, the academic staff, and the external examiners preferred the group-based project exams, although 30% of all engineering students, who had tried both types of exam, preferred an individual exam. The fact that nearly one-third preferred the – at that time, new – individual exam form was an indicator for a cultural movement to a more individually dominated curriculum and away from PBL.

These early studies also concluded that the individual exams suffered from an inability to assess core PBL process competencies, such as collaboration and teamwork. Such competencies include “complement and expand on others’ answers” and “participate in teamwork”. As argued by Mosgaard and Spliid (2011), such process-competencies are not learned without practice and involvement by the students, and the individual project exam did not assess that part of the learning. This created a situation of misalignment between the PBL teaching method and the assessment method.

In 2013, the group-based project exam was reintroduced at AAU. However, the Faculty of Engineering and Science (FES) did not simply revert to the former group-based exam model. It is now a requirement that the group exam has an individual phase inserted into it. During this individual phase, each student is questioned without the possibility of interference, or help, from the other group members. The questions put to the students during this phase are either chosen by the examiners or randomly drawn by the student from a poll of questions.

When the group-based project exam was re-implemented, we wondered how the new group-based project exam was being received by both the older students who were used to the individual project exam and the new students who had not tried any group-based project exam before. Would there now be more opposition to the group-based exam among both students and academic staff? Since we had learned that the cultural factor is an important factor in the curriculum, we furthermore wondered if there might be differences between various engineering programmes. The focus for this paper is therefore a comparison of students from two engineering programmes in relation to how they perceive the new group-based project exam.

THEORETICAL FRAMEWORK

Engineering culture and diversity

The theory of constructive alignment (Biggs & Tang, 2011) is a systemic approach to curriculum theory that offers an explanation of how the teaching system’s separate parts work and interact. It is based on constructivist learning theory stating that knowledge is actively constructed by the learners themselves through active engagement with the subject. The theory also states that in order to ensure that students learn the intended learning outcomes (ILOs), the teaching should be constructively aligned to the ILOs and to the exam. ILOs should therefore be formulated as operational competencies, the exams should measure the ILO competencies, and the teaching activities should match the ILO competencies.

The constructive alignment theory underpins studies stating that an upcoming assessment is a central factor in the students’ motivation and learning (Gibbs, 1999; Boud & Falchikov, 2006). One can, therefore, argue that in a PBL curriculum, the assessment method should be aligned with the team-based and collaborative teaching method and the ILOs on process competencies. Several studies have researched assessment methods for group projects. For instance, Willis et al. (2002) found that when assessing PBL project work, it is important that the students respond to not only the content but also the learning process: that is, the process competencies. Process competencies, therefore, constitute some of the ILOs in the curriculum. Romberg (1995) discusses the advantages of group exams and lists the following competencies: “reflection on one’s own thinking, reasoning and reflection, communication, production, cooperation, arguing, negotiating” (p. 165). Hence, it can be argued that a group exam is a suitable means to assess process competencies of communication and cooperation at AAU.

The types of problems addressed in the PBL model varies according to the profession, and AAU’s PBL model is developed “on the basis of both professional and educational argumentation” (Kolmos, Fink and Krogh, 2004, p. 9). The ILO represents the formal curriculum, but as many researchers point out, the formal or official curriculum is not the same as what is actually taught or assessed. What is actually learnt, and the cultural factor plays an important role in students learning for example, in the hidden curriculum or the experienced curriculum (Bauersfeld, 1979; Barnett & Coate, 2004; Pollard & Triggs, 1997). What we study in this paper is the students’ experience with the group-based project exam, ergo the informal curriculum, which may or may not be similar to the formal curriculum (see Table 1 below for illustration).

	Formal curriculum	Informal curriculum
Group-based project exam	Alignment among curriculum elements	This study
Individual group exam	Missing alignment for a number of curriculum elements	The study from 2007 (Kolmos and Holgaard, 2007)

Table 1. Illustration of area of study – informal curriculum

In particular, this study focuses on two different cultures within engineering. Normally, engineering is regarded as one culture, but this study has found within this discipline very different cultures and approaches to learning. Therefore, students’ attitudes are an important element in the alignment of the curriculum and we were especially concerned with individualistic versus collective approaches to learning. In engineering, technological innovation and engineering design are seen as social processes involving several individuals (Bucciarelli, 1994; Goldberg & Sommerville, 2014). Engineering education should, therefore, align the learning methods to the expected work organization (Sheppard, Macatangay, Colby, & Sullivan, 2008). However, during the last 30 years, the definition of “engineering” has become broader as new programmes have been established across traditional disciplines. Several studies indicate several differences in cultures, attitudes and motivation among engineering students from different engineering programmes, which most often are analysed according to gender and/or motivational factors for choosing engineering (Alpay, 2012; Kolmos et al., 2013).

Choice of programmes for comparison

At AAU, a new programme, Architecture and Design (A&D), combines architecture and civil engineering through a combined design approach. This programme has attracted many students that have an interest in architecture, and from the very beginning the group-based project approach has been challenged by students' expectations for a more individually oriented study programme (Kiib, 2006). Therefore, we decided to choose A&D as one of the programmes for this study. A&D provides students with knowledge, skills and competencies within the interdisciplinary field of architecture, technology and design, and students are exposed to various aspects of artistic creativity, technological knowledge, and design theories. It was decided that the other programme should be from a more collaborative area, and on examination of the programmes, we selected an engineering programme with a system-oriented approach and with a rather large number of students in order to be able to conduct comparable statistics; thus, our second programme choice was Software Engineering (SE). SE students learn to develop software focused on business and technical problems, including programming and various types of technology underpinning the interaction between machines and humans. Therefore, both programmes emphasize the relationship between humans and technology but with different foci.

Research questions

This study reveals students' attitudes to exam formats. As already stated, alignment in the curriculum is an important aspect; however, even when the curriculum elements in principle are aligned at a formal structural level, the experienced and learnt curriculum might be quite different. Therefore, students' attitudes and experiences are core elements in the analysis of an aligned curriculum.

The overall objective for this study was to discover the differences between students' experiences and attitudes to group-based project exams by comparing engineering students from A&D with students from SE. The research questions were therefore the following: (1) Do the students prefer the group-based project exam? (2) How do the students from the two different programmes perceive the individual part of the group assessment? (3) How do the students compare the former individual project exam with the new group project exam? (4) Do the students find that the examination form influences their behaviour during the project work, including preparation for the exam?

The results of these questions will help further develop an understanding of how to secure alignment between ILO and exams in general by drawing attention to not only the formal curriculum level, but also the cultural differences that might exist among different education programmes. The study will also contribute to the ongoing discussion of whether a group-based project exam is an appropriate type of exam, and whether there is a “one size fits all” in terms of assessment of PBL projects in general.

METHODS

Design of the questionnaire

In order to make some comparison with studies done at AAU since 2006, this study applied a quantitative survey using some of the same constructs (Kolmos & Holgaard, 2007). Another reason for reusing some of the same constructs was to enhance the validity of the present study by reusing constructs that have worked well previously. However, such a comparison is to be conducted with great care since the group exam prior to 2006 was different from that implemented in 2013; also, the study programmes the students are involved in would have undergone some changes.

This study collected data in two phases according to the re-implementation process of the group-based project exam, which was first reintroduced to the first-year students in 2013. In the first phase, questionnaires were emailed to all first-year students at FES two weeks after the end of all the January 2013 exams. The email contained a link to a questionnaire in SurveyXact. The purpose of the study and the researchers were introduced, and the expected time for filling out the survey was given. As part of the questionnaire, the respondents were able to add personal comments and some of these were transformed into new questions in the second phase. This component added to the validity of the study as, in fact, the January survey also functioned as a pilot study preparing for the larger study we had prepared for June 2013.

In the second phase, the questionnaires were emailed to all students at FES at the end of June 2013 when all exams were finished. As with the January survey, the email contained a link to a questionnaire in SurveyXact and provided similar information to the respondents. The questionnaire contained 20 questions, of which most of had sub-questions consisting of several items where respondents should indicate their level of agreement. We used a 5-step Likert scale with a neutral option for answers. We did not want to omit the neutral option, since we did not want to force our participants to have an opinion and, hence, jeopardise the validity; Garland (1991) furthermore argues that bias might occur both with and without the neutral option. Furthermore, we asked the students who had experienced the individual assessment of the group-based project during 2006-2012 to compare this with the new project group exam.

Response rate

In June 2013, 4,588 engineering and science students from FES received the questionnaire and 1,136 responded. This gives a response rate of 25%. Seventy-nine students were from A&D while 50 were from SE. It was unfortunately not possible to obtain the response rates from each of the two study programmes separately. The response rate of Kolmos and Holgaard (2007) was also at 25%, while the response rate of the January survey (Dahl & Kolmos, 2013) was at 36%. Below, Table 2 gives an overview of the response rates in our various studies.

Study	Response rate
2007	25%
2013, January	36%
2013, June	25%

Table 2. Illustration of response rates

The response rate was therefore lower than we had hoped for; however, this is not unusual for course evaluations or online surveys (Nulty, 2008). Paper surveys obtain higher response rates but this was not possible in practice for this study and, furthermore, Krosnick (1991) found that answers in surveys completed in class, compared to those completed online, more frequently suffer from “satisficing” where respondents tend to choose the middle ground for fear of judgement, the pace imposed, or distractions.

RESULTS

Do the students prefer the group exam?

After having tried the group-based project exam for the first time during the January 2013 exam, only 21% of the first-year students stated that they would prefer to have an individual exam (Dahl & Kolmos, 2013). These students were new to the university and had not tried the individual group project exam and could therefore not make an actual comparison. With the second questionnaire to all FES students immediately after the June exams 2013, 34% of all FES students answered that they preferred the individual exam. Here, all except first-year students were accustomed to the individual project exam. Even though the majority of the students appeared to prefer the group-based project exam, there was a difference shown between students not having any prior experience with group-based project exams and students who had been used to individual project exams. In the June study we saw a significant difference in the answers of those who had tried the individual project exam compared to those (first-year students) who had only tried the group project exam ($\chi^2(1, N =$

852) = 18.718, $p < 0.001$) with the older students being relatively more positive towards the individual exam than the first-year students. See Figure 1 below.

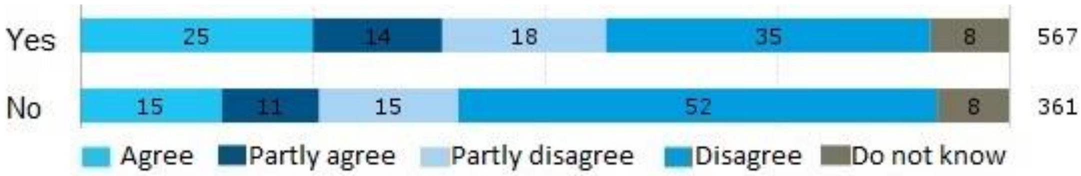

Figure 1. Answers by all students to the question: To what extent do you agree or disagree with the question: "I would prefer to have an individual project exam", compared with answers to the question: "I have tried the previous individual project exam before" (Yes/No)

Regardless of the difference, the majority preferred the group-based project exam. We had expected that the students would be more resistant to the group-based project exam, given their little previous experience with such an exam and based on the above mentioned informal reports stating critical views among the students prior to the reintroduction. When we compare these results to the studies made in 2007 where students went from a group-based project exam to an individual exam, it seems that the percentage of students preferring an individual exam is the same, despite the curriculum and experiences.

We then compared the A&D students and the SE students (Figure 2) and found that 43% of the A&D students preferred an individual project exam, while only 18% of the SE students shared that opinion. Although only a minority of both student groups agreed, we saw a significant difference ($\chi^2(1, N = 121) = 8.296, p = 0.004$) with the A&D students being the more positive towards an individual assessment.

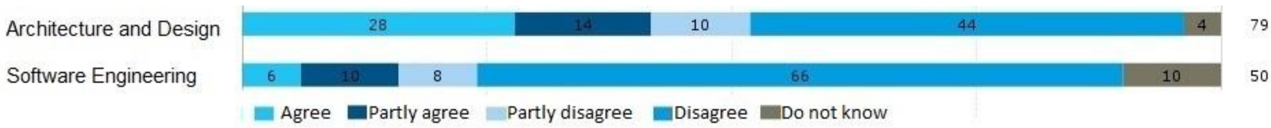

Figure 2. Answers to the question: "I would prefer to have an individual project exam"

A majority of both A&D and SE students therefore felt positive towards the group exam, but there was a significant difference in *how* positive they were. The question is, then, to what extent did the first-year students in these two programmes answer the questions above differently from the rest of the student body in these two programmes?

As illustrated below (Figure 3), we saw no significant difference between first and upper year SE students: $\chi^2(1, N = 182) = 1.712$, $p = 0.189$):

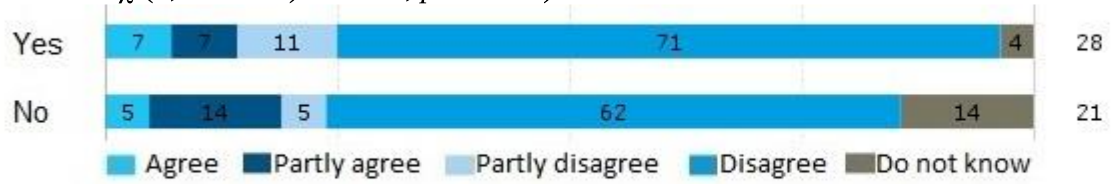

Figure 3. Answers from SE students to the question: To what extent do you agree or disagree with the question: "I would prefer to have an individual project exam", compared with answers to the question: "I have tried the previous individual project exam before" (Yes/No)

The A&D students (see Figure 4), however, showed a significant difference: $\chi^2(1, N = 192) = 23.502$, $p < 0.001$). A majority (59%) of students who had previously tried the individual project exam (older students) were in favour of the individual project exam, while a majority (70%) of students who had not tried the individual project exam were in favour of the group-based project exam (see Figure 4 below).

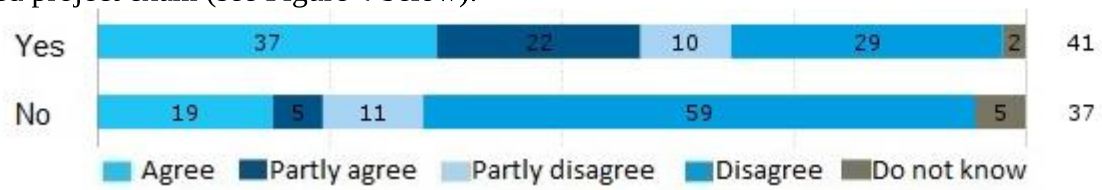

Figure 4. Answers from A&D-students to the question: To what extent do you agree or disagree with the question: "I would prefer to have an individual project exam", compared with answers to the question: "I have tried the previous individual project exam before" (Yes/No)

It therefore appears that, although the overall picture shows that students are strongly in favour of the group-based project exam, some student groups are, relatively speaking, less positive than others, with the SE students being far more positive. Also, when taking into consideration the students' prior experience with a group-based project exam, there is an evident difference. There is no significant difference between the new and the older SE students, but a significant difference between the new and the older A&D students.

How did the students perceive the individual part of a group assessment?

Regarding the question to the statement, the new individual part of the group-based exam is not necessary in order to give a fair assessment, 76% of the A&D students disagreed, while 50% of the SE students disagreed. Hence, both student groups found that the individual part of the group assessment is important to secure a fair assessment. However, the answers of the two groups were significantly different: $\chi^2(1, N = 118) = 6.483$, $p = 0.011$) (see Figure 5 below). If we compare older and new A&D students there is no significant difference ($p = 0.956$), and neither is there between older and new SE students ($p = 0.975$).

Figure 5. Answers to the question: "The individual part of the group exam is not necessary in order to give a fair assessment"

This means that, although both student groups agreed overall, the A&D students significantly felt even stronger than the SE students that the individual part of the group assessment is important. In relation to the question of whether the individual and group parts of the group exam each test different competencies while both are important, we see a similar picture: 83% of the A&D students and 65% of the SE students agreed. Again, a large portion of all students agreed and A&D students agreed more strongly than did SE students: $\chi^2(1, N = 110) = 4.497$, $p = 0.034$). There is no significant difference either between the first and upper year A&D students ($p = 0.269$), and the SE-students ($p = 0.119$).

How do the students compare the former individual project exam with the new group project exam?

All the students in the study except first-year students had tried an individual project exam and we therefore asked these students to compare the two types of project exams in a number of areas. One of the questions was about the possibility of receiving a fair grade, which is naturally something important to a student (see Figure 6).

Figure 6. Answers to the question: "If you compare the new group project exam with the former individual project exam, to what extent do you experience the opportunity to get a fair grade?"

From Figure 6, we see that the SE students answer this question significantly differently from the A&D students: $\chi^2(2, N = 68) = 14.652$, $p < 0.001$. In fact, 48% of the A&D students believed that they are less likely to get a fair grade with the group exam, compared to 21% who believed that they are more likely to get a fair grade with this exam. The opposite pattern is seen in the SE students' responses where the majority (59%) appeared to think that the group exam gives them a better opportunity to receive a fair grade compared to the individual project exam, which only 10% preferred. Between one-third (A&D) and one-fifth (SE) of the students appeared to feel that the opportunity to obtain a fair grade is the same for both exams.

We also asked the students to compare the opportunity to unfold and tell what they know at the exam. The answers can be seen in Figure 7 below.

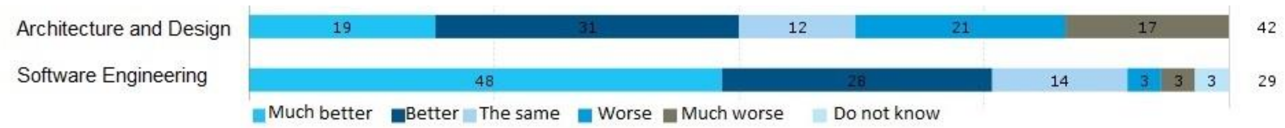

Fig. 7. Answers to the question: “If you compare the new group project exam with the former individual project exam, to what extent do you experience the opportunity to unfold and tell what you know?”

Again, the two student groups answer this question significantly differently: ($\chi^2(2, N = 70) = 8.566$, $p = 0.014$). The majority of SE students find that the group exam gives a better opportunity to unfold and tell what they know, whereas the A&D students appear more divided into two groups of almost equal size either agreeing that the opportunity is now better, or that it is worse. An similar pattern is seen in the answers to the question about the possibility of communicating their knowledge: ($\chi^2(2, N = 68) = 14.347$, $p < 0.001$). It therefore appears (again) that the SE students feel more positively towards the group project exam than the A&D students when it comes to the opportunity to tell what they know.

The students were asked to give their opinion about a number of other subject competencies tested at the two types of exams. These included questions about the possibility to receive feedback on both the subject and the project management, explain concepts, show theoretical overviews, show analytical skills, argue for methodological choices, relate various concepts to each other, transfer knowledge gained from the project to other situations and solve problems. In these areas, there did not appear to be significant differences among the two student groups, and for all of these questions the majority of students favoured the group exam.

As stated above, some survey constructs from an earlier study (Kolmos & Holgaard, 2007) were repeated in the 2013 study. Two of these questions were about “process competencies”, such as whether during the exam (1) “one can complement and expand on others’ answers” and (2) “show one’s ability to participate in a group work” (see Figure 8).

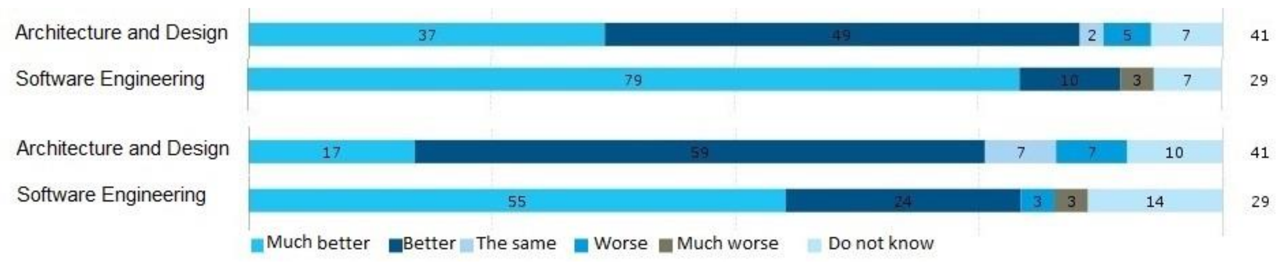

Figure 8. Answers in 2013 to the two questions: (1) “If you compare the new group project exam with the former individual project exam, to what extent do you experience the

opportunity to complement and expand on others' answers? (top) (2) … show ability to participate in a group work? (bottom)"

A majority of both student groups testified that the group exam gives them a better opportunity to show these project work competencies compared to an individual exam. Such competencies form a central part of a PBL curriculum where it is important that the exam is aligned with these competencies. The differences between the students from A&D and SE are not significant ($p > 0.6$ in both cases). This picture is, furthermore, quite similar to that from the earlier study (Kolmos & Holgaard, 2007).

Do the students experience that the examination form will influence their behaviour during the project work, including preparation for the exam?

We asked the students a number of questions relating to the fourth research question. One question asked whether knowing that they were going to be assessed in a group exam affected the way they collaborated in the group on a number of variables, such as "Distribution of work", "Mutual demand", "Desire to inform the other group members", and "Desire to once again work on a project in a group". These questions were asked in the June 2013 study because the students could compare exam forms. In relation to distribution of work, 84% of the A&D students said it had not affected them, while 93% of the SE students said the same. The difference was not significant ($p = 0.398$). An similar picture is seen in relation to the two questions about "Mutual demand" and "Desire to inform the other group members". Hence, regarding these questions, there appeared to have *not* been an effect, or just a very minor effect. However, at the fourth question – whether the students would like to work together on a project in a group again – the SE and A&D students answers were again not significantly different ($p = 0.95$) (see Figure 9), but here we saw that almost a third of the students stated that it had *some* effect. This data in itself does not show if the effect was positive or negative.

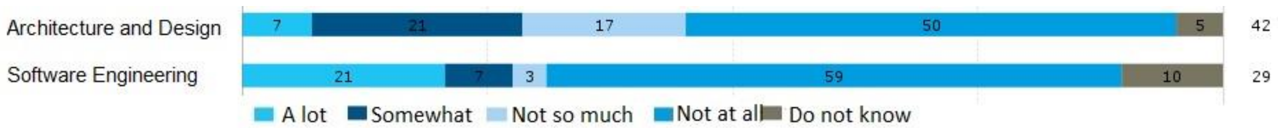

Fig. 9. Answers to the question: "To what extent has the fact that the exam was a group exam affected your desire to once again work on a project in a group?"

The students were asked about internal competition. Here, we saw that the majority of both student groups testified that the future group exam did not affect their internal competition in the group (see Figure 10), which means that the introduction of the new exam type did not alter the strength of any previous internal competition. The difference between the two students groups was not significant ($p = 0.578$).

Figure 10. Answers to the question: “To what extent has the fact that the exam was a group exam affected the internal competition in the group?”

However, in relation to the question about how it affected their exam preparation, we saw another picture, shown below in Figure 11.

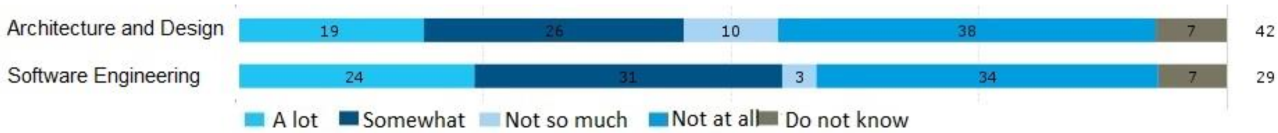

Fig. 11. Answers to the question: “To what extent has the fact that the exam was a group exam affected your preparation for the exam?”

We saw that around half the students testified that the fact that the exam was a group exam affected how they prepared for it. The difference between the two student groups was not significant (p = 0.398). In fact, one may wonder why a larger part of the students did not testify that the type of exam affected how they prepared for it. Why did not 100% answer at least “somewhat”? Around one third of the students testified that it did not affect their behaviour at all. It appears that these students either did not perceive the group exam to be much different from the individual exam (which would seem odd), or the changed exam did not, in fact, affect their preparation according to what they would otherwise have done. This might suggest that the effect of exams on student behaviour (called the “backwash” effect) is not as present in these students as is often expected and argued in education research (e.g. Boud & Falchikov, 2006).

DISCUSSION AND CONCLUSIONS

The aim of this study was to identify differences between two groups of students’ experiences and attitudes to group-based project exams – in particular, whether the students preferred the group exam to the individual. As discussed above, given that our research method was a survey asking the students about their experience with the project exam, our research is not about formal curriculum (that is, how the project exam was formally intended to be), but it is a study of the students’ experience of the informal or implemented curriculum and how the project exam was experienced. One usually anticipates that there is a connection between the formal and the informal curricula, but this is neither the focus of the study, nor something we can form conclusions about.

The study investigated the following research questions: (1) Do the students prefer the group-based project exam? (2) How do the students from the two different programmes perceive the individual part of the group assessment? (3) How do the students compare the former individual project exam with the new group project exam? (4) Do the students experience that the examination format influences their behaviour during the project work, including preparation for the exam.

In relation to the first research question, overall, a majority of the students preferred the group exam even though the minority was quite large (34%). But we also found that there was a significant difference between students not having any prior experience with project exams and students who had been used to individual project exams ($p < 0.001$), with the older students being relatively more positive towards the individual exam than the first-year students. It is, therefore, a mixed student population when one-third of the student population prefers another type of exam than that offered by the university. One reason might be that the group exam was illegal during 2006–2012 and therefore AAU had to give individual exams.

In terms of the second and third research questions about how the students from the two different programmes perceived the individual part of the group assessment and the individual project exam compared to the group-based project exam, we found that the individual project exam, as experienced by the students, was not a perfect fit in terms of alignment to PBL. This means that both the formal and informal curricula here showed misalignment. However, taking a pragmatic standpoint, one might argue that AAU found a good second option when the preferred exam type was no longer available. Both types of project exams have merit, but on the other hand, when given the option of choosing between two types of exams, why not choose the exam format that by comparison is the better one? As stated in the introduction, we nevertheless suspected that engineering students are not alike in which type of exam they experience is the best fit. Ergo, a conclusion is also that there is *not* a “one size fits all” exam when assessing PBL projects, not even PBL projects in engineering, since engineering fields are quite different from each other. But the students mostly preferred the group-based exam, even when there were significant differences expressed among the A&D and SE students. Asking the students is one way of obtaining information. Other channels are also relevant, such as questionnaires and/or interviews with teachers, examiners and study board directors, as well as observation of different exams, and calculations of marks. In this paper, we only focus on how the students experience the situation.

The results from the study indicate significant differences between A&D and SE students for several of the variables in the survey. A majority of both A&D and SE students were, for instance, positive towards the group exam, but there was a significant difference in *how* positive they were, with the A&D students preferring the individual component. Furthermore, although both student groups agreed that the individual part of the group exam is important, overall, the A&D students significantly felt even stronger than the SE students that the individual part of the group assessment is important. The different views regarding the two exams is also reflected in the 48% of the A&D students who believed that they are less likely to get a fair grade with the group exam compared to 21% who believed that they are more likely to get a fair grade with this exam, with the SE students showing the opposite pattern. These responses could either reflect that the group-based exam is, in fact, inadequate to fully secure a fair grade in architecture and design or that the exam in these programmes have not been managed properly. At least, this is how the students have experienced it.

As stated above, the A&D students had always expected more individualized study programmes and their profession afterwards might be expected to be more individualistic than that of the SE students. In that sense, one can argue that an A&D study's ILO should also be aligned with the profession; hence, it might be better for A&D students if the project exams could become more individual. On the other hand, one might argue that even though the A&D students express these views, the reaction does not necessarily have to be to adjust to the students' own perceived needs. Our conclusions are only based on the informal curriculum; thus, another option might be to enter into a dialogue with the students about these issues. If one could argue that the perceived informal curriculum resembles the formal curriculum, this might also be an argument for greater flexibility regarding how the project exam is conducted, with perhaps a need for a larger part of the four-hour project exam being individual than usually happens at present. This might also be a reflection of the fact that, prior to the reintroduction of the group-based project exam, FES held several seminars about the new exam and gave out guidelines. The idea was to describe *the* new group-based project exam, but perhaps FES needs not *one* group-based project exam, but several versions in order to properly assess the ILOs.

One might also argue that the exam was not managed properly, as also suggested just above in relation to giving marks. However, it does not make much sense to conclude that the reason for the difference is that the group exam was not properly managed for the A&D students. When the respondents were asked about their opinion on a number of other subject competencies – such as the possibility to get feedback on both the subject and the project management, explain concepts, show theoretical overview, show analytical skills, argue for methodological choices, relate various concepts to each other, transfer knowledge gained from the project to other situations and solve problems – there was no significant difference among the two student groups, and for all of these questions the majority of students favoured the group exam. Furthermore, a large majority of both student groups testified that the group exam gives them a better opportunity to show these project work competencies compared to an individual exam. The differences between the students from A&D and SE were not always significant.

It is interesting to note what exactly constitutes such differences in cultures among different engineering programmes. This study cannot reveal this, but only register that the differences do exist for the students very early in the study. However, the study raises questions about alignment and students' culture and approach to individual and collective learning.

The fact that students within one faculty are expected to learn quite different types of competencies is also seen in Brabrand and Dahl (2009) who investigated the competence progression stated in the course ILOs of different science subjects at two other Danish universities. They found that different subjects each had their own distribution of competencies they required from the students. Assuming that exams indeed test competencies fairly close to those prescribed in the ILO, it is not surprising that when asked about exams, students from different subjects behave differently and perceive the same exam type differently. We might argue that other types of students are, perhaps, even more different; the competencies they learn in their subject are different and, hence, they would perceive the oral group exam in their own way. This also includes the views of the examiners, which might affect the perception of the students. However, this was beyond the scope of this study but would be a future relevant route. Kolmos et al. (2013) conclude that there is not *one* dominant PBL Aalborg model. We might argue that perhaps AAU, as well as any other PBL university, needs even more different types of PBL models and assessment types to accommodate the quite different types of students and subjects.

A further result, relating to the fourth research question, was that we did not expect that one-third of the students would testify that facing a different type of exam than previously did not affect their behaviour at all. This might suggest that the "backwash" effect of exams on student behaviour is not as present in these students as is often expected and argued in education research. However, one might also argue that when students work in groups they might also prepare for the exam in groups – regardless of the type of exam – perhaps because they experience that this is the best way to prepare for an exam. On the other hand, it is still remarkable that one-third answered that there was no change in their behaviour *at all*.

With different exam formats, one would expect that this would create different student behaviour, just as seen above in responses to many of the other questions; hence, it is striking that this difference appears less when it comes to preparing for the exam. A hypothesis could be that the two types of exams were not really that different since both have individual components, although the group exam is carried out in the group with individual questions whereas the individual exam was conducted only with the individual student. In both exam formats, there were group presentations before the exam. Another hypothesis could be that when students become really motivated during a learning process, they are less oriented towards exams – or, phrased differently, the exam format in a PBL setting might not have the same influence and importance compared to more traditional course exams.

This raises some questions regarding the hypothesis on alignment in curriculum, and especially the importance of assessment. Educational change might be very difficult if all curriculum elements always have to be aligned. It might be that sometimes a misaligned curriculum fosters motivation for change. However, one might also argue that in a misaligned curriculum it might be very difficult to foresee and prepare for how students might act, and in fact what they learn.

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Motivating Students Through Positive Learning Experiences: A Comparison of Three Learning Designs for Computer Programming Courses

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ABSTRACT

Based on the assumption that wellbeing, positive emotions and engagement influence motivation for learning, the aim of this paper is to provide insight into students' emotional responses to and engagement in different learning designs. By comparing students' reports on the experiential qualities of three different learning designs, their respective influence on students' motivation for learning is discussed with the purpose of exploring the relationship between positive emotions, engagement and intrinsic motivation for learning. Our study thus aims at evaluating the motivational elements in the three learning designs. This experimental, controlled comparison study was conducted in an introductory computer programming course. The three learning designs were: 1. A traditional teacher-led course; 2. A problem based learning (PBL) course; and 3. A PBL course combined with the use of LEGO Mindstorms Robots.

Three different methods were used for collecting data on the students' experiences and feelings: 1. A questionnaire survey with 229 students from groups exposed to the three different learning designs; 2. Six qualitative walk-alongs collecting data from these groups by informal interviews and observations; 3. Six class room observations. Findings from the three studies were discussed in three focus group interviews with 10 students from each learning design in order to validate these findings.

The research was conducted among first year students in Computer Science at the Informatics School, Universidad Nacional de Costa Rica.

Keywords: emotions, motivation, engagement, experience criteria, experience design, learning designs, problem based learning, LEGO Mindstorms, computer programming courses

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SECTION I: INTRODUCTION

With the global increase of university students, failure rates have become a worldwide concern. This is also the case with the retention of first year students in Computer Science (O’Kelly & Gibson, 2006). Specifically, programming courses are generally regarded as difficult, and often have the highest failure/dropout rates (Robins, Rountree, & Rountree, 2003). The Informatics School at Universidad Nacional in Costa Rica is no exception. In the period between 2008 and 2012 the average failure rate (including dropouts) of the introductory programming course was 47.2%.

This increase in failure rate has generated interest in identifying factors affecting success in an introductory computer-programming course. A study by Wilson & Shrock (2001) examined whether factors such as math background, gender, previous programming experience, encouragement, comfort level in the course and work style preference, have an influence on success. The results showed that the comfort level was the strongest influencing factor followed by math background. The authors emphasized the importance of providing students with a comfortable and non-intimidating environment that motivate them to learn thus pointing at the role of emotions in learning.

Motivating students has always been a challenge. In Jenkins (2001) the author studied four types of motivation in computer science undergraduate students: extrinsic, intrinsic, social, and achievement. The results suggested that extrinsic motivation is strong, that is, a large number of students are motivated to study computer programming because they believe they will have rewards such as better opportunities in their professional life. This study also showed that an almost equal number of students are intrinsically motivated, meaning that they are really engaged in their learning process for the sake of developing skills. Moreover, the author pointed out, that intrinsically motivated students seemed to be more interested in learning in general rather than specific learning of computer programming. This study showed that it is not straightforward to understand and to stimulate the motivation of computer programming for students.

One recent trend to make computer science courses more exciting and interesting to students is the use of programmable LEGO Mindstorms robots (Blank, 2006; Klassner & Anderson, 2003; Cliburn, 2006). It is widely believed, in spite of some divergent results (Fagin & Merkle, 2002; McNally, Goldweber, Fagin, & Klassner, 2006), that the use of LEGO Mindstorms provides students with a motivating learning environment (McWhorter & O’Connor, 2009). Learning strategies such as critical thinking and metacognition, required to effectively learn computer programming, have been shown to be related to students’ motivation (Bergin, Reilly, & Traynor, 2005). Moreover, robots are well suited for encouraging creative problem solving because they combine technological knowledge with soft skills such as team skills and complex problem-solving strategies (Hees, Jeschke, Natho, & Pfeiffer, 2011).

On the other hand, some authors (Hamalainen, 2004; Nuutila, Törmä, & Malmi, 2005) have stressed that a problem-based learning approach (PBL) can contribute to motivate students and reduce failure and dropout rates. PBL contributes to develop students' learning through teamwork skills, hands-on practice skills, problem solving skills, and project organization and planning skills (Kolmos, Fink, & Krogh, 2004). Due to its inductive nature, PBL is believed to have a strong impact on the intrinsic motivation for learning, because students can understand the purpose of what they are learning (Prince & Felder, 2006). In addition, the approach promotes active and collaborative learning, and greater student responsibility in his or her own learning process (Prince & Felder, 2007).

In order to investigate further the effectiveness of using PBL and LEGO Mindstorms robots to influence student motivation and reduce failure and dropout rates, an experimental, controlled comparison study was carried out in an introductory programming course at the Universidad Nacional in Costa Rica. The study compared three learning designs for the introductory programming course: (1) a problem-based learning (PBL) design; (2) a combination of PBL and LEGO Mindstorms (PBL+LM) learning design; and (3) a traditional learning design (control group) using classical teacher-led lectures and black boards.

The overall aim of the study was to gain insight into and evaluate the influence of the learning designs on students' motivation for learning. This paper reports the results related to the students' *emotional response* to their learning experience, thus scrutinizing the findings by Wilson & Shrock (2001) that a comfortable and non-intimidating environment motivates students. These emotional responses express the hedonic qualities of the learning environment and the learning designs. As such they are key factors in students' attraction or repulsion to the course. Based on research in motivation (Higgins, 2006; Higgins & Scholer, 2009), this paper furthermore examines the impact of the learning designs on the strength of student motivation by also looking at these designs *engaging qualities*.

The goal of our study was thus to examine whether there was a relationship between the students' feelings – e.g. whether they felt happy/sad, bored/stimulated, involved/disinterested, nervous/safe etc. – and their intrinsic motivation for learning. This relationship is the learning experience, understood as the experiential value of the learning process as reported by students during and after this process. We have examined these student experiences by using the ten criteria characterizing "positive experiences", developed by Jantzen et al. (2011).

The remainder of this paper will proceed as follows. Section II defines experiences, their learning potentials and their relation with emotions. This section also presents the ten experience criteria used to analyze students' emotional response. Section III reviews and discusses related research on LEGO Mindstorms Robots and on Problem Based Learning. In section IV an overview is provided of the study methodology and the three learning designs utilized. Section V presents the results, whereas section VI discusses the findings. The paper closes with discussing the implications of our research in section VII.

SECTION II: EXPERIENCES, EXPERIENTIAL LEARNING AND EXPERIENCE CRITERIA

As pointed out by Higgins (2006) the experienced value of a product or process (e.g. learning) is a matter of both hedonic experiences (i.e. pleasure or pain) and engaging experiences (i.e. intensity of engagement). The hedonic experiences determine the direction of the motivation. They make products and processes seem attractive or repulsive. The force of the motivation, though, is a result of both hedonic and engaging experiences. Engagement thus contributes to the degree (i.e. the strength or intensity) in which users are motivated and feel attracted to or repulsed by the product or process. An experience is in our study understood as a cognitive awareness of physiological and emotional changes in the organism (Jantzen, 2013). These changes have a hedonic valence. The awareness generated in experiencing challenges existing cognitive structures and may lead to an increased knowledge of the self and the world.

Implied in this definition is the coherent and dynamic character of experiences. An experience is coherent, because it integrates physiological, emotional and cognitive aspects. It is dynamic firstly because actual experiences mark a difference from previous ones and because actual experiences are the foundation of future experiences. In experiencing, the present is related to the past (as expectations to be challenged) and to the future (as formation of memory). Secondly experiences are dynamic by encompassing an "undergoing" and a "doing" (Dewey, 2008). We are passively exposed to experiences: They happen to us and we respond to their hedonic qualities emotionally ("an undergoing"). But we are also and at the same time actively seeking experiences: They motivate us by engaging us ("a doing").

Experiences have learning potentials. Experiential learning is a continuous process that transforms the impulses, feelings, and desires of concrete physiological and emotional experience into higher-order purposeful action (i.e. meanings). In that way the experiential learning style is purposeful and motivating (Kolb, 1984). By such transformations, experiences become the basis of new knowledge or of new practices. At the same time they engage us to continue or intensify the learning process.

Positive experiences contribute actively to the self's physiological and emotional wellbeing by eliciting positive emotions: e.g. emotions related to rewards, which are thus attractive. Our use of experience design criteria is motivated by knowledge from positive psychology confirming that well-being and positive emotions promote cooperation between individuals (Seligman, 2000), are intrinsically motivating (Isen & Reeve, 2005), facilitates problem solving, broaden our scope of attention and modes of thinking (Frederickson, 2001; Frederickson & Branigan, 2005) and improves the understanding of the situation (Isen, Daubman, & Nowicki, 1987).

In measuring differences in experience and the emotions generated by the three different learning designs the 10 criteria of "positive experiences", introduced by (Jantzen et al., 2011), were used to develop the semantic differential questionnaire and guide the collection and analysis of interview and observation data. These criteria are firstly derived from theories on the psychology of experiencing (Jantzen, 2013) thus covering physiological, emotional, cognitive and social (e.g. identity issues) aspects: How and in which degree does the design for example promote emotional or cognitive aspects? What are its transformative qualities? Secondly, they stem from analyses of successful cases of experience design: Which structural features in the design do apparently have positive experiential effects? How does this particular design stand out from other designs, and which effects does this imply?

These experience criteria therefore cover different dimensions of experiencing:

- Psychological aspects: whether the design is involving, relevant, interesting, and provide learning and understanding
- Structural aspects: whether the design is interactive, authentic, original, spontaneous and persuasive.

Criteria	**Key questions**
Interactive	Informants' comments whether they feel an active part of the design: Do they feel that they are invited as co-players, co-producers or co-creators?
Near	Informants' comments whether they find that the design "talks to them": Does the design address their situation, their interests or their problems?
Intimate	Informants' comments whether they feel obliged to participate: Does the design make them feel related, are they persuaded or convinced to become active or take responsibility?
Authentic	Informants' comments whether they find the design authentic: Is the design sincere, true?
Unique	Informants' comments whether they find the design original: Is it something that they have not experienced or encountered before?
Involving	Informants' comments whether they feel emotionally involved: Is the experience exciting, relaxing or reassuring?
Lively	Informants' comments whether they find that the design allow them to be spontaneous: Do they feel that the design encourage them to dig into the design?

Learning	Informants' comments whether they find that the design is supporting the learning process and the creation of experience: Does it challenge what they already know? Does it broaden their horizon?
Understanding	Informants' comments whether they obtain understanding: Does the design facilitate the user's comprehension of situations, intentions, potentials, etc.?
Interesting	Informants' comments whether they find the design interesting: Is it providing something unexpected? Does it have their interest? Does it surprise?
Relevant	Informants' comments whether they find the design relevant: Does the design relate to the existing mental concepts?

Table 1: Sums up the 10 experience criteria and illustrates the key questions used to address the students' experiences and feelings. The ten criteria also guided the observation of students' emotional reaction in class and during project work.

Some of these criteria express the degree in which the design involves its users emotionally and hedonically (Liveliness, Involvement). Other criteria cover the users' physical (Interactivity) or personal (Nearness, Intimacy) engagement in the designs. And others again are cognitive (Relevance, Interest) or related to self-development and self-transformation (Learning, Understanding). Some criteria can be used to measure the design's ability to motivate or persuade (Involvement, Liveliness, Intimacy), others for assessing its openness to active user participation and collaboration (Interactivity). Still others point to the surprising (Uniqueness, Interest) or sound (Authenticity, Relevant) qualities of the design.

The 10 experience criteria are meant to cover the complexity of experiencing and the motivational direction and motivational force implied in having an experience. We therefore consider them to be useful metrics in measuring the relationship between the feelings generated by the three learning designs and in measuring how to promote student motivation for learning.

SECTION III: REVIEW OF RELATED RESEARCH

Finding a method to make teaching of computer programming more motivating for students is a global challenge. The following section describes some previous results obtained when introducing LEGO Mindstorms or a PBL approach in teaching computer programming. The three learning designs used in our study (section IV) build on these results.

Experiences with LEGO Mindstorms Robots

Research on the use of LEGO Mindstorms robots in computer programming courses shows mixed results. One of the main advantages related with the use of LEGO Mindstorms is that these robots do not confine students to the constraints of a computer screen; instead they afford to teach computer-programming concepts using physical real world systems. In this vein, Garcia & McNeill (2002) stated that LEGO Mindstorms allowed students to control and manipulate computers in the real world making learning of introductory computer programming concepts more fun. In Lawhead et al. (2002) the authors argued that the robot is a real physical object, and as such very useful to teach concepts of object-oriented programming. Learning object-oriented programming is easier when students are offered physical objects that have the ability to "feel" their environment and react to it. This is in contrast with a traditional programming environment, which is often perceived by students as artificial or abstract. The robot can establish a direct relationship between programs and observable behavior, which is more satisfying for students as they can see the direct effect of their coding in robots, and get an immediate response if the robot does not behave as expected. This direct relationship between source code and its effect makes the testing phase really fun for the participating students (Lawhead et al., 2002).

In the same vein, Anderson & McLoughlin (2007) mentioned that the lack of immediate and successful results that often comes with learning programming can have a negative impact on student motivation. This frustration can lead students to falling behind, failing the exams, and eventually dropping out of the study program. This situation is even more serious, given the lack of patience exhibited by current programming students.

In Cliburn (2006) it is described how LEGO Mindstorms were used in an introductory computer science course to introduce students to abstraction, algorithms, and problem solving. The author used the visual programming interface included in the LEGO Mindstorms software arguing that this allowed students to focus on problem solving rather than on learning the syntax of a programming language. This study recommended the use of LEGO Mindstorms as a tool to teach algorithms and foster student creativity.

A research project made by Wong (2001) set out to study whether the use of LEGO Mindstorms robot activities could provide a more effective and motivational learning environment than the traditional Integrated Development Environments (IDE) which is common in most computer programming courses. The author included three weeks of LEGO Mindstorms activities on diverse levels of computer science courses. The author claimed that the students seemed to retain learned knowledge better in the LEGO sections than in the traditional ones.

On the other hand, there are also studies with non-favorable results. In Barnes (2002) the author indicates that it is impractical to use LEGO Mindstorms to teach an entire introductory programming course, mainly because of issues such as inconsistencies in the motor voltage and the possible confusing use of loop structures. Instead robots, he argued, may be used to support the learning of programming concepts in a traditional course setting.

In Fagin & Merkle (2002), the authors reported the results of one year of experience in the use of LEGO Mindstorms activities in an introductory computer programming course. The aim of the study was to see whether the use of LEGO Mindstorms could improve student performance and determine the influence of robots in encouraging students to select computer science or computer engineering as a field of study. The study compared the results of more than 800 students on identical tests from both robotics and non-robotics-based laboratory sessions. The results were negative. Test scores in the robotics groups were lower than in the non-robotics groups, and using robots showed no measurable effects on the students' choice of field of study. To explain these results the authors argued, that students in robotics groups must run and debug their programs on robots during assigned lab times, and therefore were deprived of time for reflection and of the compilation-run-debug cycle outside the classroom environment, which is an important part of the learning process. This also drastically reduces the amount of time available for reflective thinking on non-trivial projects given to students over several days.

Similarly, McNally et al. (2006) concluded that there are logistical and pedagogical disadvantages in the use of robots. As logistical disadvantages the author outlined the costs, arguing that it is too expensive to provide each student their own robot which implies that every student-experimentation are limited to the available lab time in class, and this is insufficient to promote open experimentation with the robot. Regarding the pedagogical disadvantages, LEGO Mindstorms robots limit the scope of object-oriented concepts to which students can be exposed, because the robot did not support the exploration of concepts such as polymorphism or the interaction of multiple classes and objects. Other pedagogical disadvantages are related with the robots operating in a continuous world. This means, for example, inconsistency of robot movements due to differences in battery power, and the need for frequent calibration of sensors to respond to the changing nature of the physical environment. The authors argue that while the skills learned to program in a continuous environment are valuable and useful, they are not essential in the curriculum of computer science, and as such should not be the focus of the introductory students' experience.

Especially the practical time issues that diminish the time for reflection and limit the possibility of introducing a broad set of programming concepts, has caused debate on how to include activities with LEGO Mindstorms robots in introductory programming courses. Despite this, its use has become increasingly common at colleges and universities, because it is assumed that the use of these robots contributes to motivating students due to the close relationship both to real-life problems and between programming and observable behavior of the robot. Overall, the use of robots provides a holistic, cognitive as well as embodied feel for programming.

We have planned the PBL-LM learning design learning based on these findings by integrating theoretical lectures about programming theory in the project work when relevant, and by providing one robot per group throughout the programming course.

Experiences with PBL approaches

Problem-based learning (PBL) is a student-centered approach to learning, in which students learn through the process of solving an open-ended problem. PBL builds on constructivist principles, involves active learning and promotes collaborative learning (ACM, 2013; Prince & Felder, 2006; Hissey, 2000). The method strives to resemble a work-based scenario, either in the exploration and definition of a problem or as a simulation of a real-life project with more than one way to solve the problem or to implement the solution. Students work in small groups with the teachers as a supervisor or facilitator rather than a teacher. The method has the potential to achieve a higher motivation and greater responsibility in the learning process because students learn to be more independent in their approach instead of relying totally on teachers (Dirckinck-Holmfeld, 2002; Loyens, Joshua, & Rikers, 2008; Isen et al., 1987).

Problem-based learning encourages students to face real problems as a starting point for the acquisition and integration of new knowledge (Prieto, 2006). The approach promotes the development of skills such as problem solving, decision-making, teamwork and communication skills. These characteristics are particular useful in computer engineering. The ability to solve problems is vital in the discipline and many of the activities of professionals in computer engineering are framed in the development of projects. Accordingly ACM (2011) identifies a set of skills that future graduates must have, such as problem solving, efficient communication, effective collaboration, professional responsibility and the capacity of lifelong learning.

The effectiveness of PBL versus lecture-based teaching has been analyzed in several studies in the higher education context. The results are contradictory. According to Kinnunen & Malmi (2005), the results favor one or the other depending on whether the emphasis in learning is on the acquisition of factual knowledge or on self-directed learning skills, social skills and motivation. PBL may increase skill levels, but may result in poorer performance on traditional test subjects and it could also be stressful for students. Therefore some PBL learning designs include lectures, exercises or other pedagogical activities.

In Nuutila et al. (2005) the researchers identified a significant decrease in the dropout rate in a study which introduced PBL in introductory programming courses. The authors argued that in addition to learn programming students acquire skills in collaborative work, independent studying and communication. In the same vein, in a study on introducing PBL to teach theoretical concepts from computer science (Hamalainen, 2004), the author concludes that the dropout and failure rates decrease when students follow a PBL approach compared to a conventional one. Furthermore, the author reports a greater commitment of the students to the PBL course in comparison with a traditional one.

Difficulties in using the PBL approach have also been identified. PBL involves a cultural change, both for students and teachers. In general, students are used to lecture-based methods of teaching, which promotes students to adopt a passive attitude and casts the instructor in the role of expert. Other problems are related to the main characteristics of PBL: problems as stimulus for learning, tutors as facilitators and group work as stimulus for interactions (Dolmans, De Grave, Wolfhagen, & van der Vleuten, 2005). In some learning environments students are confronted with too well structured and closed problems. In this case, problems are too simple to challenge students to construct knowledge actively. Another aspect hindering the PBL learning process is a too dominant or too lenient supervisor, which may provoke tension and conflict in groups leading to lack of commitment and student absenteeism (Dolmans et al., 2005). Regarding group work, some groups tend to be dysfunctional showing lack of cohesion and poor motivation, which obstructs the collaborative nature of learning (Kinnunen & Malmi, 2005; Dolmans et al., 2005). According to Dolmans et al. (2005), it is necessary to conduct further research to identify how PBL can stimulate students towards more constructive, self-directed, collaborative and contextual learning.

We based the development of the PBL learning designs in our study on these findings. We related the theoretical concepts to real-life problems in the lectures and developed three broad project topics that the students utilized to formulate specific problems for their project. We divided the available lecture hours into two parts: a) lectures combined with small lab exercises and b) independent, student-led project work.

SECTION IV: DESIGN OF THE STUDY

We have seen that robots have the potential to engage students in the learning of computer programming. In addition our assumption was that the potentials of learning with robots are further increased when this technology is combined with PBL that supports a broad collaborative learning process and allow the presentation of more programming concepts and provide time for group discussion.

The study utilized data from students enrolled in the course EIF200: Introduction to Programming during the first semester of 2013. The course taught the basic principles of object-oriented programming and lasted 16 weeks with a student workload of 8 hours per week.

The research design for the study was an experimental, controlled comparison study, which compared three learning designs: (1) a problem-based learning (PBL) design; (2) a combination of PBL and LEGO Mindstorms (PBL+LM) learning design; and (3) a traditional teaching design (control group).

The study involved 15 groups of students and included a total of approximately 300 students and 12 faculty members. Each learning design was used for 5 groups. Each group in the Control and PBL groups consisted of a maximum of 25 students, and the groups in the PBL+LM design had 20 students.

The study used 30 LEGO Mindstorms sets that were donated by The LEGO Foundation in Denmark. All students were included in the study with the exception of students who dropped the course and stopped coming to class.

A. The three learning designs

The three designs have several activities in common, as showed in table 1, but the PBL and PBL+LM learning designs have been designed according to the basic PBL principles supporting free, continued development of real world problems, process-oriented interaction, collaboration between students and professors, interdisciplinary problem-solving, self- and peer assessment, and a dynamic curriculum (Newman, 2005; Savory, 2006). Lectures do not have any weight on student scores, wherefore they do not appear in the table.

	Control	PBL	PBL+LM
Problem-based project	10%	20%	20%
Learning activities (homework and quizzes)	25%	15%	15%
Attitudinal evaluation	5%	5%	5%
Exams	60%	60%	60%
Total	100%	100%	100%

Table 2: Distribution and evaluative weight of learning activities per learning design (in percentage)

As shown, the PBL and PBL+LM learning designs have the same distribution of workload. The main difference with the learning design for the Control group concerns the learning activities and the project. The increase in the learning activities (homework and quizzes) was to compensate for the minor workload assigned to the project work. In all three designs the students took three exams, which together weighed 60% in the final grade.

Regarding the teaching approach, the participating professors in the PBL and PBL+LM learning designs introduced small problems to explain the various course topics (for example loop structures and arrays) while the professors in the learning design for the Control group consisted of teacher-led presentations of the topics either using the blackboard or a power-point presentation. In addition, the PBL and PBL+LM designs offered several challenges to the students throughout the semester to promote collaborative learning. In order to foster autonomy and responsibility for their own learning process the students in those learning designs were confronted with self-assessment and peer assessment strategies for each of the collaborative tasks (Rios, 2007).

In the case of the PBL and PBL+LM learning designs, the students were put in groups of 4-5 persons to work on the project. They had to choose from three different project topics formulated by the professors. These topics were described in an open-ended manner, so the student groups had to decide on the definition of the problem and the way to implement it. The projects in the PBL learning design addressed the use of bi-dimensional arrays while the projects with the PBL+LM learning design dealt with challenges for the robot, e.g. to collect trash. In the case of the learning design for the Control group there was only one project with a very detailed and structured description, leaving little room for independent development of the project.

All groups in the PBL+LM learning design participated in a five-week sequence of lab activities using LEGO Mindstorms Robots. Construction of the robots was done in the first week. Robots were used to introduce selective (if-then-else) and iterative structures (while, do while and for). During the lab sessions the students worked in groups of 4 to 5 members. The C++ language was used for programming the LEGO robots. The decision to use C++ and not the visual programming interface included with LEGO Mindstorms software was to have all three learning designs using the same object-oriented programming language. The software used during the LEGO lab sessions was Microsoft Visual Studio 2010. Each group had their own robot to practice the lessons. In addition to the lab time the students could work with the robot in their own time but without taking the robot outside the university premises.

B. Data collection methods

User experience evaluation means investigating how a person senses and responds to a product, design, event or service (Vermeeren et al., 2010). It includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments occurring before, during and after use. The evaluation of user experiences is complicated by the fact that experiences are subjective, context-dependent and dynamic over time (cf. section II). They are subjective because they rely on the mood, knowledge and momentary interests of the user. They are context-dependent in being influenced by circumstances in the immediate surroundings (weather, noise, accessibility etc.) as well as by larger social issues and cultural agendas. They are dynamic because new experiences relate to older ones and because memory transforms the quality and value of a past experience.

To study the learning experience our research used mixed methods comprising qualitative as well as quantitative methods:

- Study 1: A semantic differential questionnaire was developed to examine the students' connotative perceptions of and attitudes to the learning design.
- Study 2: The walk-along method was used to obtain opinion data and sensory information on the learning experience. This method consisted of a combination of interviews and observations while the student groups were working actively on their projects (Kusenbach, 2003;Lykke & Jantzen, 2013).
- Study 3: Non-participant observations of classroom interactions were made to obtain insight into students' behavior and emotions while being taught.
- Focus group interviews were conducted at the end of the empirical studies to validate the findings from the three other forms of data collection.

The walk-alongs were planned to last an hour for each project group, and consisted of 3 steps: 1) an introduction to the procedure; 2) observation of the project work while walking-along; and 3) follow-up interviews primarily to get demographic data about age and programming experience. The students and the walk-along facilitator met outside the classroom immediately after lecture. After a short introduction to the research project and the walk-along methodology, the facilitator walked along with the students, firstly to find a location for the group work, later to participate in the project work. On the way the PBL+LM groups picked up the LEGO Mindstorms tool box at the janitor's office. All groups had problems finding a place to work. Two groups worked at the library, two groups in the outdoor patio, and the two PBL+LM groups in a computer room with small computer tables and limited floor space for working on and with the robot. During these walk-alongs the students were instructed to act and work as usual. The facilitator observed the group work, took notes, especially about the students' interactions and mood, and asked clarifying questions about the students' emotions and experiences with the project work and collaboration. The 10 criteria of the "positive experience" guided the observation and questioning. After an hour the facilitator closed the walk-along by collecting demographic information. All walk-alongs were taped. Immediately after the walk-alongs the facilitator made a summary of the course, summing up the students' way of working focusing on the atmosphere and the emotional signature of the project work.

The non-participant observation took place during lectures in the classroom. The observer was briefly introduced and placed at the back of the room. She took written notes on the course of events and the atmosphere in class. These observation studies were also based on the 10 criteria of "positive experiences".

Findings from the questionnaire survey, walk-alongs and non-participant observations were discussed in three focus group interviews, one for each of the learning designs. The focus groups aimed at elaborating the understanding of the central research themes: students' experiences, learning outcome, personal development and collaboration between students. Ten students from each of the three learning design groups participated in these focus group interviews.

SECTION V: PRESENTATION OF RESULTS

In the following section results from the three studies will be presented and discussed. Findings from the focus group interviews will be included in our discussion (section VI). We start by summing up results from the semantic differential questionnaire that provide a simple, quantitative picture of the students' attitude and feelings about the learning designs. We use opinion, 93avourabl and sensory data collected during the walk-alongs as well as data from our non-participant observations to discuss the findings.

229 students filled in the questionnaire, 70 students from the control design, 86 students from the PBL design, and 73 students from the PBL+LM design. 6 project groups participated in the walk-alongs, 2 for each of the three learning designs, a total of 21 students. Non-participant observations were made in the classroom during lectures, 2 lectures for each learning design: i.e. 6 lectures involving a total of 118 students.

In the questionnaire survey there was a total of twelve pairs of opposite adjectives for the students to consider. The adjectives were related to negative or positive emotional states that one might have experienced during the course:

- Sad vs. Happy
- Annoyed vs. Comfortable
- Dissatisfied vs. Satisfied
- Melancholic vs. Delighted
- Despairing vs. Optimistic
- Bored vs. Stimulated
- Stressed vs. Relaxed
- Calm (tranquility) vs. Excited
- Slow vs. Hectic
- Nervous (anxiety) vs. Safe
- Sleepy vs. Lively
- Insignificant vs. Interested

They were placed adjacently on a scale with boxes that represented intermediate values. The students were told to put their mark in accordance to the box that best fitted their feelings during the lectures; the closer to the respective adjective the stronger the feeling. The students were also asked to provide supplementary comments about the respective course activities, in particular if they had experienced something interesting, challenging, or motivating. The method provided a semi-objective evaluation of the students' emotional responses to their respective introductory course; control group, PBL, and PBL+LM. It was made clear to the students that it was not a test of their performance.

For analytical purposes we categorized the replies to the questionnaire survey on a nine-point scale ranging from -4 over 0 to +4 between the pairs of adjectives; a negative value laden adjective and a positive value laden adjective such as the aforementioned "happy/sad", "bored/simulated", and so on.

Upon this categorization we divided the nine-point scale into three parts. -4 to -2 were the very negative replies, -1 to +1 were the neutral replies, and +2 to +4 were the very positive replies. We then calculated the mean value of each of these parts, cf. table 3. The mean values made it possible to illustrate the differences in a radar chart, as can be seen in fig. 1. A negative mean value connects to a negative value laden adjective, and the reverse goes for positive values. Thus, in Table 3 the mean value 1,6 indicates an average feeling of sadness for the Control group and the values 2,0 and 2,2 an average feeling of happiness for the PBL and PBL+LM groups.

In general, there were only slight differences in the students' feelings, and the differences were triggered by a small set of students, between 1 – 30 students out of approximately 80 students, depending on the differential. We will now present these differences in the following descriptions.

Variable	**Control**	**PBL**	**PBL+LM**
Sad/Happy	1,6	2,0	2,2
Annoyed/Comfortable	1,9	2,3	1,9
Dissatisfied/Satisfied	1,7	1,9	1,5
Melancholic/Delighted	2,0	2,1	1,8
Despairing/Optimistic	1,9	1,4	1,7
Bored/Stimulated	2,0	1,8	1,9
Stressed/Relaxed	-0,1	0,6	-0,2
Calm/Excited	1,1	1,1	1,1
Slow/Hectic	0,6	0,3	0,3
Nervous/Safe	-0,1	0,9	-0,1
Sleepy/Lively	1,1	0,7	1,0

Insignificant/Interested	2,9	2,7	2,8

Table 3: Mean values of emotional scales

In the following subsections we will go into more detail on the semantic differentials of each of the three learning designs. For this purpose we have given each number on the scale its own color respective to the value it represented. The warm colors represented the negative value laden adjectives of each of the 12 pairs of adjectives. Reversely, the cold colors represented the positive laden adjectives. The size of each of the color-coded bars represented the amount of replies connected to that given value. This allowed us to look for overall patterns between the three learning designs with ease.

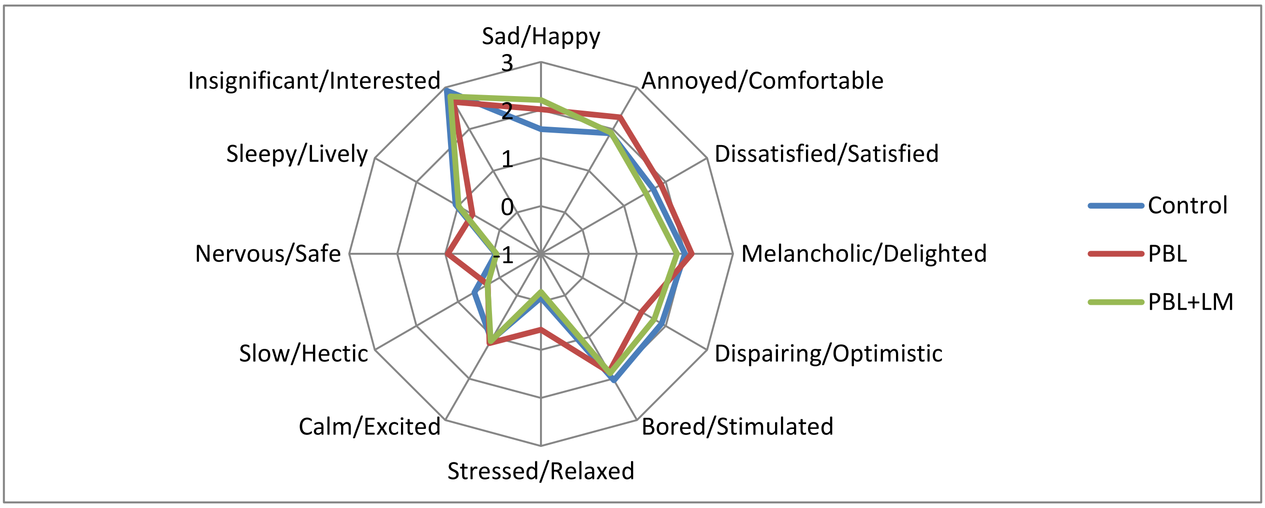

Fig. 1: Radar chart of emotional scales

For the practical purpose of reading the graphs by color, we removed the numbers of how many students replied a certain value, which were situated in the middle of the color-coded bars. We will instead present the relevant numbers in the following descriptions. Also note that one of the pairs of adjectives "slow/hectic" can have multiple meanings, since "hectic" for instance may not be a positive feeling in all given situations, even though it is connected with the positive color coding in our graph. In general, there were only slight differences in the students' feelings, and the differences are triggered by a small set of students, between 1 – 30 students out of approximately 80 students, depending on the differential.

E. The Control Group

By looking at the color-values of the control group in fig. 2, we can see the students felt positive about the learning experience, but some also felt stressed and nervous. A small amount also felt bored and sad, but more or less everyone agreed that the course was interesting, cf. no negative colors at "insignificant/interested" in fig. 2.

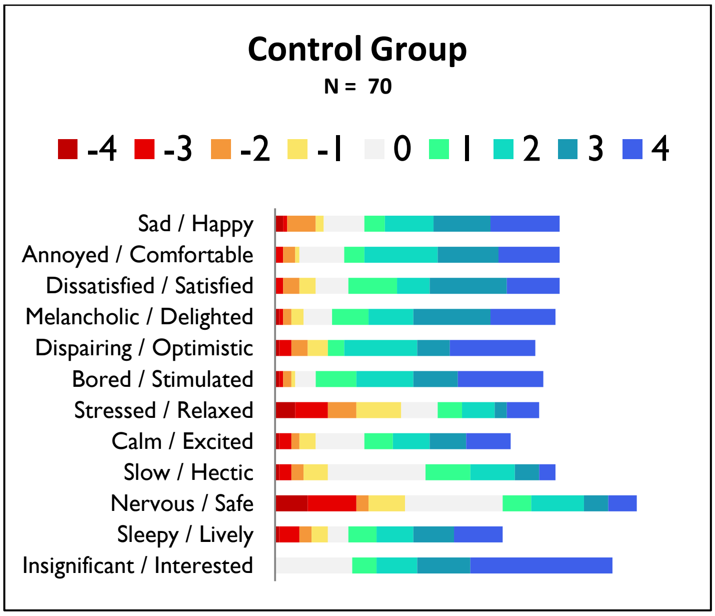

Fig. 2: Semantic differentials for the Control Group students.

The number of students who replied they felt between -2 to -4 values of stress was 20 out of 68, which means that at least 29% of those who replied felt some amount of stress. Likewise, the number of students who felt some amount of nervousness was 33% of the 70 students who replied. 14% replied they were sad and 6% replied they were bored.

The observational data confirms the findings. In the control groups the professors used either the blackboard or a power point file to present the logic of the programming in a sequential manner. The professors were relaxed, interacted in a living and cheerful way with the students, and involved them in the teaching. Some few students took directly part in the dialogue answering questions from the professor, but the majority of the students followed the teaching with attention and interest, but passively. Judged on their expressions some students seemed distracted. Some seemed to have trouble understanding the lecture, but only few consulted the professor with questions. Some students small-talked during the lecture disturbing the concentration of other students. Both active and passive students used their mobile during class. A small group of students discussed the programming problem and solution among them independently of the professor, but most students left initiative and organization of the learning process to the professor.

The Control group students made a small project as part of the course, which was observed during the walk-alongs. Compared to the classroom teaching the control group students were more involved and enthusiastic in the project work. They tried out solutions, consulted the Internet for information, and discussed solutions. However, as in class, some few specific students took the lead of the project work, and in general the students expressed frustration being without the guidance of the professor.

B. PBL

Looking at the color-values in the PBL course in fig. 3 we see a similar pattern of overall positive experience with some amount of stress and nervousness. The number of students who felt happy seems to be a bit higher than in the control course. Some students also found the PBL course to be somewhat insignificant.

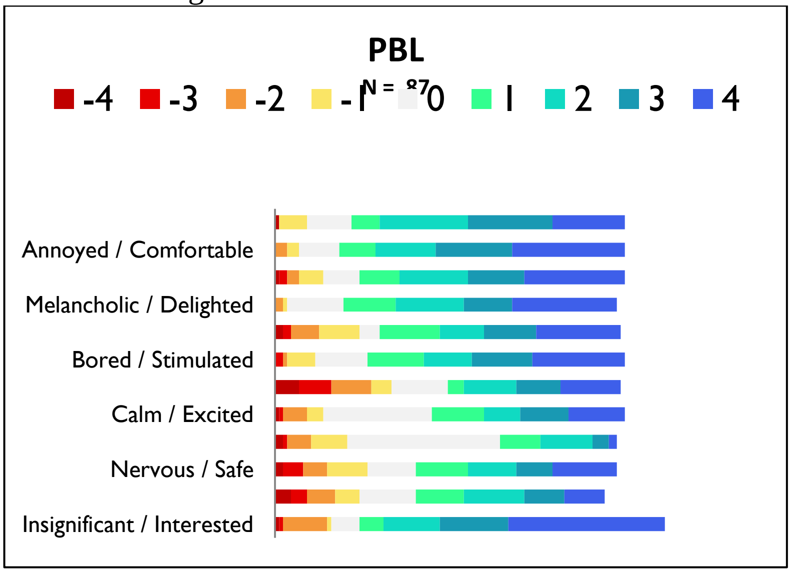

Fig. 3: Semantic differentials for the PBL group students.

The number of students who replied they felt between -2 to -4 values of stress was 24 out of 86, which means that at least 28% of those who replied felt some stress. The total of students who felt somewhat nervous was 16% out of the 86 students who replied.

Only 1% felt sad and 3% felt bored, which is an improvement when compared to the Control groups' course.

Looking at the number of students who felt the course was somewhat insignificant, 3 students out of a total of 87 replied they felt between -2 to -4 values. This amounts to 3% of the total population in PBL.

Again the observation and walk-along data confirm the questionnaire findings. Both PBL classes were held in a form continually switching between a short lecture, an instruction by the professor, and group work. In total there were three small group work sessions during the observed class. As in the control group the tone was lively and joyful with a close contact between the professor and the students. The students paid attention to the professor and participated with comments and questions. There was laughing, and the students expressed involvement and interest. Not all students participated actively, but only one group of boys in one of the PBL classes used their mobiles and small-talked. During the project work, the students worked very interactively, exchanging and discussing ideas, clearly trying to apply concepts from the lecture and using the course terminology. There was a lively, relaxed and humorous atmosphere with friendly competitive and reciprocal teasing – e.g. in regard to who knew the proper terms or who found the best solution to the problem. Many of the discussions was about the "best" or "right" way to solve the problem. No specific plan or task organization was made for the work. The students did not divide the tasks between them, all contributed continually. Most group members participated actively. Generally, the students highlighted the realistic tasks that they found enriching and very motivating.

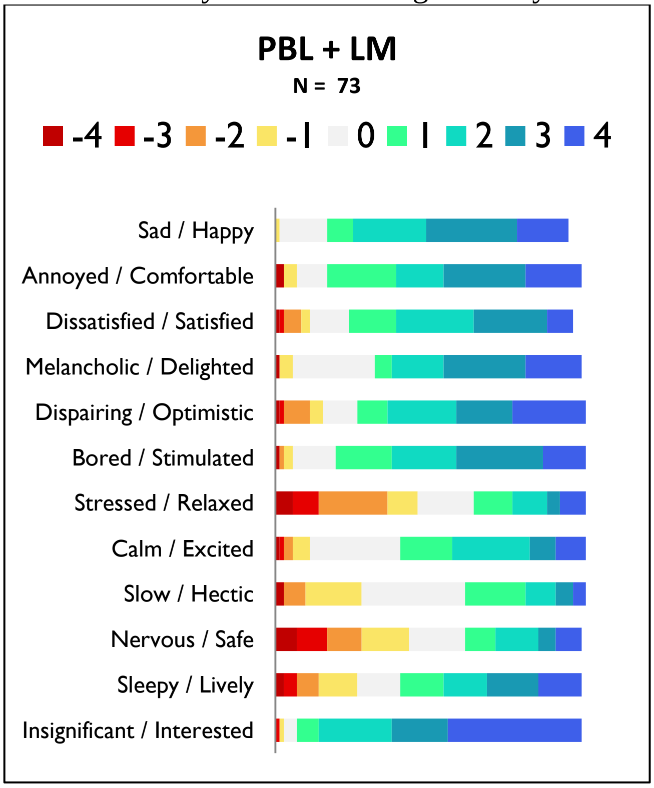

Fig. 4: Semantic differentials for the PBL+LM group students.

C. PBL + LEGO Mindstorms

The color-values in the PBL+LM course show a similar pattern as with the other two course types; stress and nervousness being the dominant negative states of feeling. The number of students who replied they felt between -2 to -4 values of stress was 26 out of 72, which means that at least 36% of those who replied felt some amount of stress. The total of students who felt some degree of nervousness was 28% out of the 71 students who replied.

None of the 68 students who replied felt sad, while 3% of the 72 who replied felt bored. One student felt the course to be somewhat insignificant. He replied that he felt a value of -3.

The PBL+LM class consisted of project work, with only a short introduction to the programming subject by the professor. The students were very concentrated in their work, continually switching between programming the software and trying out the results with the robot. In general all students were involved. The students worked very structured and divided the work into tasks or roles, e.g. adjusting the algorithm, consulting the literature or the teacher, operating the robot, or repairing the robot. In most groups one or two of the students took the lead and organized the work; typically the ones who operated the computer or the robot. Thus, all students were interested and participated interactively. All felt related to the work, but the students participated with various degrees of involvement and liveliness. Some expressed frustration when they repeatedly had to make small algorithmic changes in order to have the robot circle or turn. The professor worked around the class and participated actively in the work. Sometimes the students had to wait for help.

For the PBL+LM students the start of the project work was slow and annoying because the students had to pick up the robot at the Support and Development Unit, find a room, and build the robot. The groups also had problems and used much project time to set up the communication between the computer and the robot. In addition, they had problems finding floor space to try out the programming on the robot. However, the atmosphere was good. The students were very interested in the task. They sat close to each other while working, discussed solutions, and tried out solutions. They were very engaged and helped each other.

We have now presented the students' emotional responses to the three learning designs and will now compare how these designs score on negative emotions. Our assumption is that "positive experiences" relate to lower scores on this set of emotions. Lower scores are thus assumed to be 99avourable to learning.

D. Stress & Nervousness

By illustrating the semantic differentials in the color-coded graphs we have revealed that there is a clear pattern of stress and nervousness in each of the three learning designs. To see how much the courses differ, we will now compare the findings from each of the three learning designs.

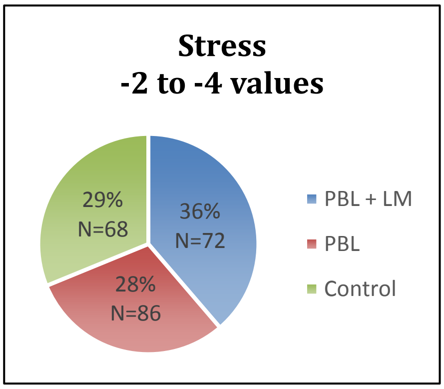

Fig. 5: Stress values across learning designs.

Comparing the percentages of students who feel stressed in each learning design, we find that the PBL+LM course scores the highest, cf. fig. 5. Interestingly, the PBL course, which only differs slightly in its approach compared to PBL+LM, scores the lowest of the three.

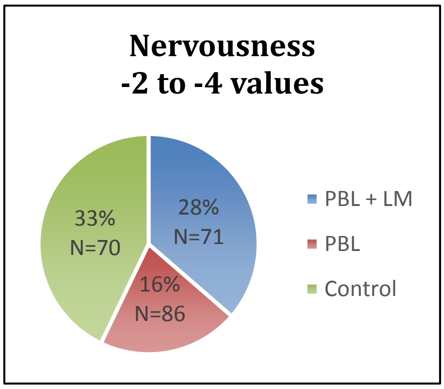

Fig. 6: Nervousness values across learning designs.

Looking at the percentages of students who feel some degree of nervousness, once again, the PBL course has the lowest score, cf. fig. 6. It is also somewhat surprising that the Control group course scores the highest percentage, considering the novelty of the learning designs in both the PBL and the PBL+LM courses.

E. Sad, Bored & Insignificant

When comparing the percentages of students who feel sad in each learning design it is quite noticeably the Control group course that scores the worst, cf. fig. 7. With 14% feeling unhappy there is clearly a difference compared to PBL and PBL+LM, which scores 1% and 0%. Still, a simple glance at the color-coded graphs reveals that the majority of the students feel happy in the respective course types.

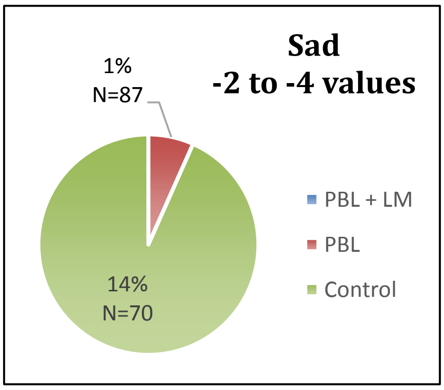

Fig. 7: Values for sadness across learning designs

Looking at the percentages of students who feel bored, once again the Control group course scores the worst, but only with a three percent increase compared to PBL and PBL+LM, cf. fig. 8. As in the case of feeling sad, the color-coded graphs reveal that the majority of the students felt stimulated in their respective course types.

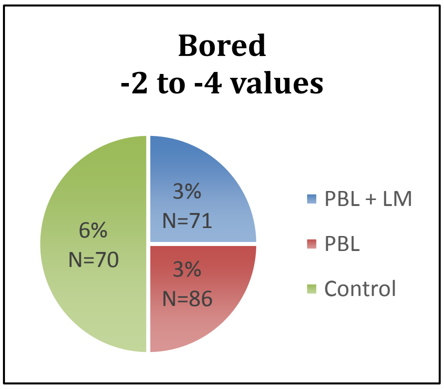

Fig. 8: Values for boredom across learning designs.

The amount of students who felt their course type was insignificant is only 1% in the PBL+LM course and 3% in the PBL course, cf. fig. 9. Interestingly, there is no one in the Control group who felt their course was insignificant.

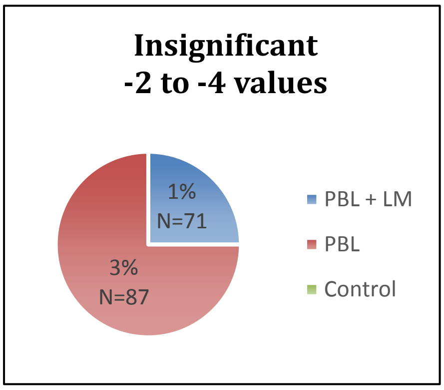

Fig. 9: Values for insignificance across learning designs.

The focus group interviews provided additional explication for the findings. Working with the robots was very motivating and interesting for the students. The students considered the possibility of working with robots as an interesting, fun and exceptional opportunity. They liked to work interactively with the programming, liked the trial-error learning style that was essential for the robot work. However, the students experienced a lack of theoretical knowledge that could guide them through the trial-error process. It provided a feeling of insecurity and doubt – e.g. “do we learn what we should”, “do we obtain sufficient theoretical programming knowledge”. In addition, the students felt a time pressure, because they used much time to pick up and assemble the robot and find a place to work. They were also frustrated because they did not have sufficient space or appropriate physical conditions to try out the robots.

The Control groups were satisfied to have a professor that systematically presented programming concepts and guided the problem-solving process. It made them feel safe about the learning outcome. They also liked the one small project work. However, when they had to plan the work themselves, they felt unprepared and insecure about the process and the group work – questions raised were of the type: “How do we approach the problem?” “How are we to organize the work?” “How are we supposed to work together?”

The PBL groups enjoyed the dynamic interplay between lecture and group work and the collaborative interactions with the professor in class. The interactive learning style in class provided a feeling of security, and the students felt comfortable and prepared for the project work. The PBL students highlight the trial-error learning process and they experienced the collaborative interactions between individual considerations, ideas and experience from co-students and guidance from the teacher as interesting, challenging and fun.

SECTION VI: DISCUSSION

The aim of this study was to learn about the influence of learning designs on students' emotions and on their intrinsic motivation for learning. Based on the assumption that experiential value is derived both from hedonic experiences and from engagement (Higgins, 2006), the study focused on the students' *emotional response* to and their *feeling engaged* in these designs. Ten criteria of "positive experiences" were used to study the emotional qualities of the designs. These criteria cover different dimensions of the learning experience – whether the students feel that they learn something, derive pleasure, comfort or inspiration from this learning, whether they work in an interactive and collaborative environment, feel motivated, and feel responsible for their own learning process etc. The use of experience design criteria is motivated by knowledge from positive psychology confirming that well-being, positive emotions and self-activity promote cooperation, are intrinsically motivating, broaden the scope of attention and thinking and facilitate problem solving.

Our research shows that the learning designs influence the students' physiological and emotional wellbeing (i.e. their emotional responses) as well as their active engagement in the learning process. Working with the robots was experienced as engaging by the students. The students considered the possibility of working with robots as an interesting, fun and exceptional opportunity. They liked to work interactively with the programming, felt motivated by the trial-and-error learning style that was essential for working on and with the robot. Nonetheless, they also expressed frustration and de-motivation when they repeatedly had to make tiny changes in the programming code. They felt that insignificant programming details shifted the focus away from more general programming principles. Additionally, students experienced a sense of insecurity and doubt about the learning outcome, mainly due to a perceived lack of theoretical knowledge to guide them through the trial-and-error process. Furthermore, they felt a time pressure because whenever they were required to work with the robot, they needed to pick it up, to assemble it and to find a convenient place to work. All these activities took much time and distracted them from the programming work. The strength of PBL+LM learning design is the project work and a high degree of interaction and collaboration, whereas the students miss the freedom to develop and frame the purpose of the project. Likewise, the nature of the robot work force the students to divide tasks between them, thus narrowing the students' learning experience. At the same time, the inherent limitations in developing real world programming tasks by using the robot is a challenging obstacle for the learning design.

The PBL groups enjoyed the interactive collaboration with the professors and the dynamic interaction between lectures and group work, which took place in the classroom. Contrary to the PBL+LM students the PBL students did not divide the tasks between them. No specific plan or task organization was made for the work, most PBL students contributing continually and interactively, thereby potentially engaging each student in an optimal way and allowing them to obtain a broad learning experience. In the same vein, the interactive learning style in class provided a feeling of security, and the students felt comfortable and prepared for the project work. The PBL students highlighted the trial-and-error learning process and the collaborative interaction between individual considerations, ideas and experiences from co-students and guidance from the teacher. The collaborative work was challenging, but primarily experienced as interesting and fun: i.e. as emotionally rewarding. As it might be expected from previous literature, the PBL-approach provided a productive environment for experiental learning. In the present set-up, however, the degree of freedom to develop the problem and to plan the problem-solving process may still be improved providing more challenges and skills to the students.

The Control group primarily received teacher-led lectures with a small, well-defined project as part of the course. The majority of the students followed the teaching with some degree of attention and interest, but they did it passively. Only some few students took directly part in the dialogue answering questions from the professor. The overall intensity of the motivational force appeared significantly lower than in the two other designs. Generally speaking, the students left the organization of the learning process to the professor, seemed satisfied to have a professor that presented programming concepts and guided the problem-solving process. It made them feel safe about the learning outcome.

Nevertheless, they appreciated the one small project work, felt motivated by the realistic problems and the collaboration with other students. However, when they had to plan the work themselves, they felt unprepared and insecure about the process and the group work – questions raised were of the type: "How do we approach the problem?" "How are we to organize the work?" "How are we supposed to work together?" The strength of the classroom learning design is its potentials for continuity and control of the learning outcome. However, the Control groups seem prone to a feeling of stress and nervousness. They did not feel prepared to take responsibility for their own learning and collaborative work. And they expressed frustration when being without the guidance of the professor to motivate their learning process.

Except for the semantic differential questionnaire that was filled out by 229 students, with a response rate of 69%, the study is small with 2 walk-alongs and 2 classroom observations per learning design. The findings would be stronger if walks had been conducted with all 15 project-groups and if there had been walks at intervals during the whole learning period. Such approach would have provided a broader picture of the group work and would have allowed the researchers to gain more insight into the developments in the students' work processes, their collaborative behavior, and their engagement in group work and programming theory. To compensate for this lack, the explicit aim of the follow-up focus group interviews was therefore to validate the findings and thus provide a broader picture of the learning designs. The focus group interviews that were carried out with both students and faculty (each group apart) allowed us to compare findings across project groups giving us with a more nuanced picture of the learning designs.

We deliberately chose to carry out the walk-alongs at a point approximately at mid-point in the course. The idea was to meet the students when they had worked with the learning designs for some time, overcome unavoidable start problems and gained experience with these new ways of learning.

The combination of quantitative, less nuanced information from the semantic differential questionnaire and the situational and detailed insight from the walk-along and observation studies gave a nuanced picture of students' experiences. The data supplemented and supported each other pointing to the same findings. Specifically we found it useful to go from surprising results from the semantic differential data, e.g. telling that traditional class-room learning scored well on interest and low on stress, to the narratives and explanations in the walk-along conversations.

SECTION VII: IMPLICATIONS

Summing up, all three learning designs have their own set of advantages and challenges. The PBL-design seems best at stimulating collaboration, interaction, and emotional wellbeing. The robots in the PBL+LM-design are engaging and motivating, but also frustrating, due to the inherent limitations of the robot regarding project tasks, practical issues and insecurity about the learning outcome. The traditional class lectures provide security in terms of theoretical insight, but also provide stress and nervousness due to little or lacking experience with working actively and collaboratively. If we want happy, comfortable, delighted, and at the same time calm and lively students, none of the learning designs are completely satisfying. It is also clear that all of the students are motivated by working in projects, but for the robots to become an effective tool for motivation it is necessary to provide more theoretical knowledge about programming and to improve the project tasks and the conditions under which the robots are used in the course.

Concerning the use of LEGO Mindstorms robots the results underpin the importance of practical issues. There should be one robot per group, each group should keep their robot during the full project period, and appropriate physical environments with sufficient space for working with the robots should be provided. The idea of integrating and relating the theoretical lectures directly to the practical work with the robots worked well. However, it should be clear for the students how the small lectures relate to the overall curriculum. If not this way of lecturing may cause uncertainty whether "we learn what we should". The students' emotional response to traditional lectures shows the strength of close contact between students and lecturer. The lecturer provides security and also interest and motivation by prioritizing and structuring the theoretical subjects. PBL turned out to be the most motivating and engaging approach. However, the students expressed less interest and stimulation compared to traditional teacher-led courses. This is surprising. The findings show the importance of the guiding role of the teacher. This group of students, students for whom self-directed, independent group work was a new phenomenon, appreciated the teacher's road map and directions.

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The Use of System Thinking Concepts in Order to Assure Continuous Improvement of Project Based Learning Courses

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ABSTRACT

This case study describes a continuous improvement experience, conducted from 2002 to 2014 in Sao Paulo, Brazil, within 47 Project-Based Learning MBA courses, involving aproximatelly 1.400 students. The experience report will focus on four themes: (1) understanding the main dynamics present in MBA courses (2) planning a systemic intervention in order to improve the following courses (3) doing the intervention and analysing the results (4) assuring the continuous improvement.

Keywords: Project-Based Learning, Systems Thinking, Community partners

DESCRIPTION OF THE CONTEXT

In 2002, the first author was invited to teach a capstone course on "Project Simulation" to finalize a two-year long Project Management MBA offered by University of Sao Paulo, Brazil. The MBA program offered a number of Project Management related courses (Project Planning and Control, Risk Management, and so on). The "Project Simulation" course was conceived with the goal of giving students hands-on experience and the opportunity to apply what they had learned during their MBA studies. In designing the twelve-week long "Project Simulation" course, the professor decided to use Project-Based Learning (PBL) techniques.

Each class met for three hours. In the first half of the class the professor gave a lecture about system dynamics techniques applied to project management. The students worked in the projects on the second half of the class.

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The students worked in teams. The number of team members was related to the complexity of the project scope. We can say, that, in average, the number of team elements was five. They did several different kinds of projects, such as small buildings reforms (painting, windows replacement, renovation of bathrooms for the elderly), acquisition of equipments (computers, furnitures, refrigerators, air conditioners and many other equipments), purchase of food, blankets and clothes and organizing activities for children (Christmas and New Year's parties, gymkhana).

During the course period they intensively exchange information with Community Partners. Many of project activities involved fundraising. The students obtained the necessary resources in a variety of ways: by seeking donations from corporations, selling raffle tickets, organizing fundraising events (like workshops and parties), soliciting donations from people of their social networks, and so on.

THEORETICAL FRAMEWORK

Project-based learning (PBL) is approach to learning gaining more and more attention in the later years. PBL can be understood as team activity that is carried out over a defined period of time, with the purpose of creating a product or service (Donnelly and Fitzmaurice, 2005). According to Savery (2006, p.16) "the learning process is oriented to follow correct procedures and teachers act as instructors and coaches". There are Universities were Problem and Project Based Learning pedagogies are becoming integrated to institutional objective (Barge, 2010, p. 9). However, in spite of all this development, we think that there are some gaps in available literature related to the practical issues of creating and sustaining effective PBL courses. In our point of view, the key questions is how to make the PBL an experience that bring benefits to all involved (schools, students and community)?

For the this question, Palmer (2010) discusses the concept of a learning space, where the groups of students can learn with each other and share experiences.

The purpose of this report is to discuss practical ways of assuring students and teacher engagement to PBL courses, to present ideas of creating and maintaining a reliable network of community partners and to discuss a method of managing effectivelly PBL courses.

We believe that four components contributed to the success of the experience. First, the understanding of the structure responsible for the course dynamics. Based on that, we took actions to reinforce the virtuous cycles and create additional ones. Second, the course followed a well-structured project-based learning approach. Third, we work closely with a reliable network of community partners. Fourth, the professor had support from his institution and was given the autonomy to change, redesign and improve the program, assuring a continuous course improvement.

CONCRETE IMPLEMENTATION AND ACTIONS

In order to understand the course dynamics, we used concepts from System Dynamics Theory. We used causal loop diagrams (CLD) and followed the modelling process proposed by Sterman(2000). With CLD we create a model for the course dynamics, based on what we observed during the classes. Models are simplification of reality, but they can bring us insights of the main dynamics present. We created our model based on our experience as modellers and we think the model was a valid description of the problem that we were interested in.

At the end of the first course taught, in order to gain further insight, we drew a casual loop diagram (CLD) for the feedback processes in the course. Figure 1 shows that students' motivation to work would lead to higher quality team work and better overall project results. Over time, students would be motivated to work on projects that led to high quality results. We named this first reinforcing feedback the "*students' morale*" loop. In turn, high quality projects would motivate and engage the professor himself, who would then be more motivated to improve the quality of educational resources. A high quality faculty involvement would increase students' motivation and encourage better quality work. This reinforcing feedback we named the "*professor's morale*" loop.

There are also two negative feedback loops related to fatigue. Both professor and students become more tired during the course development. The fatigue would impact negatively on the motivation of professor and students. We named these negative feedback loops as "Students fatigue" and "Professor's fatigue".

This initial model (Figure 1) shows the dynamics of the first course taught; we created this model to have a better understanding of which variables needed intervention in order to make the subsequent courses successful.

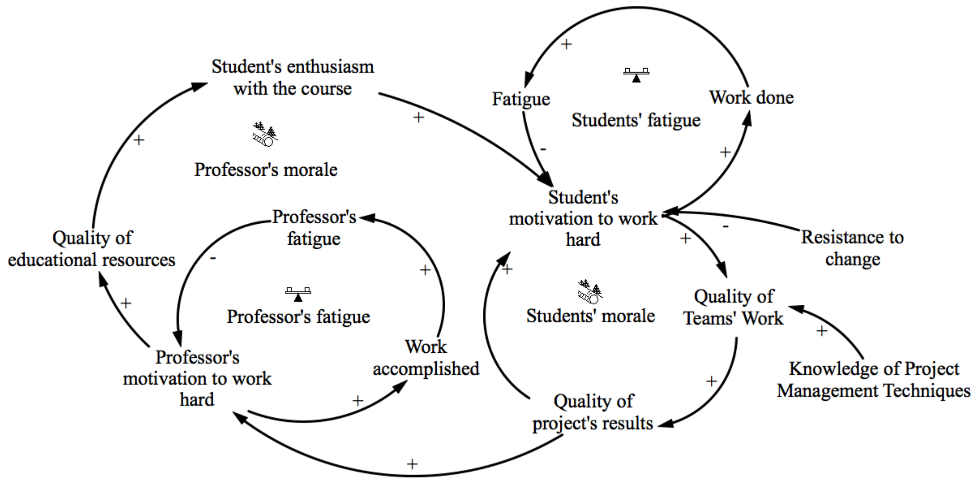

Figure 1. Causal Loop Diagram shows the main feedback loops

PLANNING THE INTERVENTION FOR THE FOLLOWING COURSES

It was clear to us that we could boost students' enthusiasm and commitment by improving the quality of educational resources and the teaching methodology. By improving both the students' and the professor's morale, we could let the reinforcing loops driving the dynamics operate in a virtuous way.

To change students' perception of and attitude toward the course, we considered the options available for improving the quality of educational resources (e.g., lectures, class notes, etc.) and the teaching methodology (using PBL concepts).

We saw that if the professor's motivation increased, he would devote time and effort to improve the quality of educational resources (e.g., write a course related book, create a course's website). The improved educational resources would then raise students' enthusiasm and close the reinforcing feedback loop , that of "*Professor's morale*".

We consider to develop partnerships with NGOs engaged in humanitarian works. We anticipated that the development of partnerships would bring exciting project's themes to the students, increasing theirs feelings of participating in something valuable. In parallel, we expected that if quality of projects' results grow, the number of succesful projects would increase leading the strengthening of the partnerships. Those actions would create a new reinforcing feedback loop, named "Building Partnerships".

The growth in the number of successful projects would also reduce students' resistance to change. If students saw a high number of projects completed successfully, their resistance to change would disappear. The reinforcing loop associated with these dynamics is captured in the "*Breaking resitance*" loop.

Finally, if the quality of project's results increased, the community partners' motivation would also increase, leading to a higher interaction between the students and partners, increasing the student's enthusiasm with the course. This last reinforcing loop was named *"Partner's morale".*

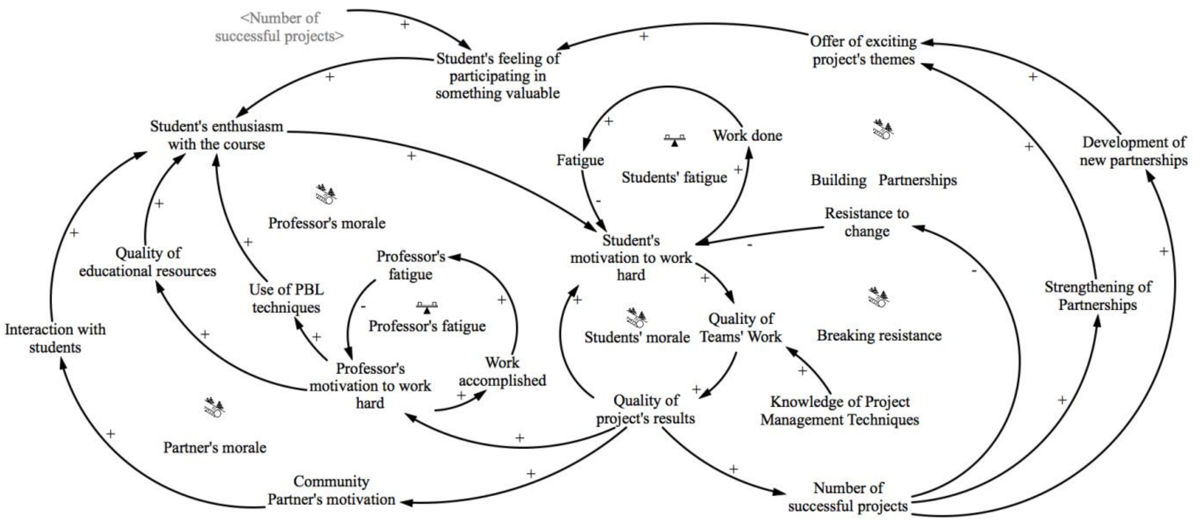

Figure 2: Causal Loop Diagram created in order to plan the intervetions for the following courses.

The use of CLD in order to understand the course dynamics is very important. As Senge et. al (Senge et. al, 2012, p. 129) pointed out, "behind each pattern of behavior there is a systemic structure... when studied these structures reveal the points of greatest leverage." The pattern of behavior of the students is consequence of the course structure. If we want to chance their behavior, we need to work on the structure.

ACTING ON THE FOLLOWING COURSES

Once we understood the dynamic drivers of performance captured in the comprehensive CLD, it was clear which improvement policies would help achieve the desired course outcomes. Since we figured out that the students' enthusiasm was the key variable, we focused on improving this. In particular, in the subsequent courses, we focused on the following:

1. *Creating of a PBL environment*
2. *Establishing relationships with community partners, in order to offer exciting project themes*
3. *Improving the quality of educational resources*

CREATING A PBL ENVIRONMENT

Our PBL environment tries to agregate key elements reported on several researches on the field (Blumenfeld et. al, 1991), (Richmond, Manokore, 2011), (Barge, 2010), (Bell, 2010).

Based initially on Thomas (1999) and later on Larmer & Mergendoller (2010), we created an environment that allowed the students to develop project management skills, giving to them the opportunity to work in real-life projects, with real clients.

We established processes of revision and critique of the projects, at the second part of each class. We also brought questions to our students that led them to in depth studies. In our environment, the students had freedom to chose the client, the project theme, the team members. They were also free to decide their roles and responsibilities. They were free to chose the fundraising strategies, to contact and establish partnerships with corporation and local community.

ESTABLISHING RELATIONSHIPS WITH COMMUNITY PARTNERS IN ORDER TO OFFER EXCITING PROJECT THEMES

We contacted a number of NGOs in São Paulo, through COMAS, the City Council for Social Welfare, an entity that works with NGOs. From this action we got our first partner, a NGO that worked with children and teenagers of poor neighbourhood. The NGO provided several professional courses to them, helping in the development of their skills. The MBA students worked with enthusiasm, accomplishing projects that brought all kind of resources to that NGO. The success of the students' projects led to strengthen of this partnership. The NGO learned to trust in the iniciative, bringing new project themes for the following courses. Moreover, the NGO invited other NGOs to participated. The word-of-mouth process began. Along the years, the process repeated itself and the new NGOs became partners.

The students had a important role in this process. In each class of students, sometimes we had ones that worked as voluntary in NGOs that were not our partner.

The students asked us permission to invite that NGO to participate in the next course, as a new partner. We always welcome new community partners. In this way, the students contribute to the ampliation of the virtuous cycle.The whole process of creation a network of reliable partners took several years, it was a slow process. In addition to NGOs, we have worked with Public Institutions (City Counties, Public Schools, Public Hospitals and Community Centers). Our advice to PBL community is that, more difficult than to create a partnership, is to chose the right partner, to keep the partnership and to educate the partner to work with students.

IMPROVING THE QUALITY OF EDUCATIONAL RESOURCES

The quality of lectures and support material improved dramatically. Each lecture was carefully planned and improved, term by term, year by year. The idea was to create motivating lectures that would awake the interest of students for the subjects covered.

We replaced the handouts given to students with books specifically designed to be used in this course. This process was done in a incremental way, every couple of year a new book was released, with revised content and new topics. We also created a website to support the course, with video recorded lectures. The course website provided information about previous years' projects, allowing students to have access to extensive information (eg. project management plans, reports, lessons learned catalogue, videos and so on) of all previous projects.

RESULTS AND REFLECTIONS

From 2002 to 2007 the number of projects undertaken was relatively small, 19 projects. Until 2006, students worked together on a single project. By the end of 2007, we changed it. The projects started to be done by small teams of students (five students at maximum). Adding to that, in 2007, the Project Simulation course was also offered to another very similar MBA course, taught by the same professor, following the same method. This other MBA course had equal structute, but was designed to IT professionals. Both changes caused the number of projects per year to increase (Figure 3).

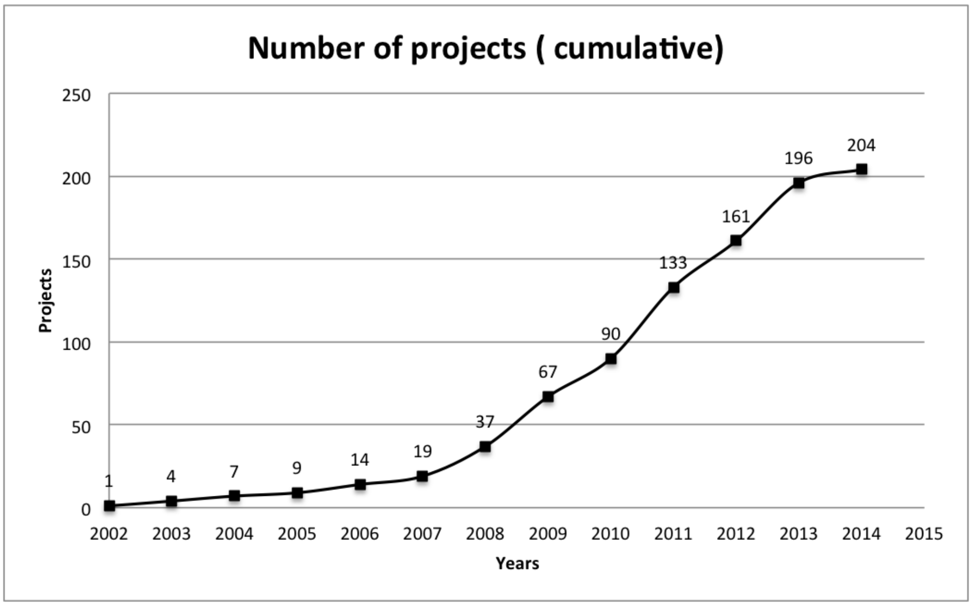

Figure 3. The cumulative number of projects, from 2002 to 2014

Figure 4 shows that almost half of projects (47, 5%) involved goods acquisition (equipment, books, food, toys etc.). Another half involved the sum of activities as reforms, product creation, systems development, marketing actions, service creation and trip support.

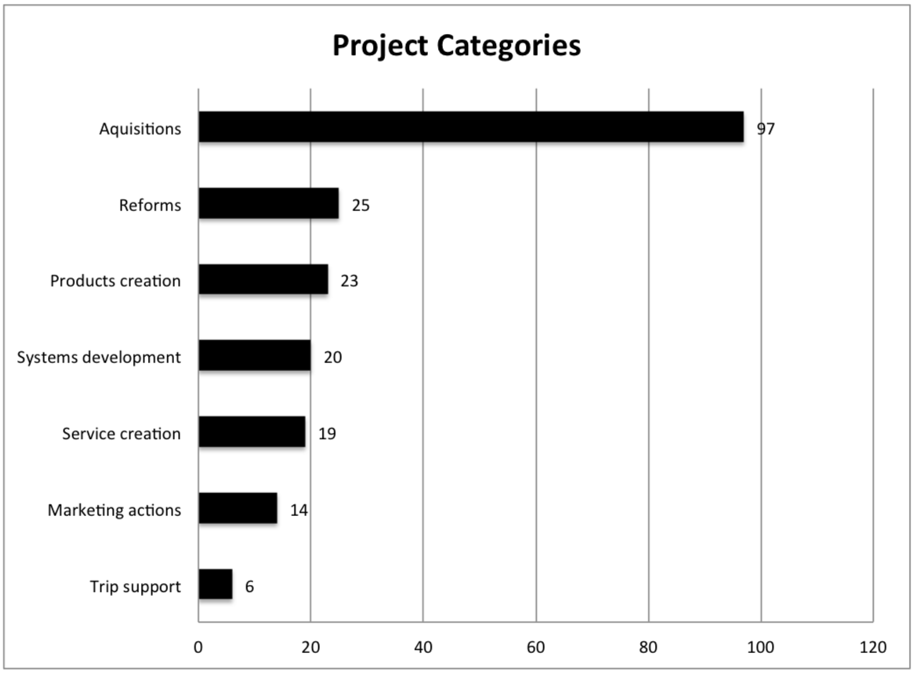

Figure 4. Project Categories

Sixty eigth percent of the projects involved fundraising activities, thirty two percent didn't.
The students obtained resources they need from raffles in 37% of the projects, from corporation's donations in 33%, from individual donations in 25% and from fundraising events in 5% of projects. We can say that one hundred and fifty five projects accomplished (76%) had medium complexity, twenty one (10%) were complex and twenty eight (14%) had low complexity. In terms of the quality of the project documents, 57% of the projects were very well documented (blogs organized, with all plans and documents created during the project), 13% of the project were fairly documented and 30% of projects were poorly documented. From the 204 projects accomplished, one hundred and sixty five (81%) can be considered successful. Twenty projects (10%) had partial success (the project failed to achieve the requirements or the schedule). Nineteen projects (9%) can be considered failures.

COMMUNITY PARTNERS

From 2002 to 2014 we have worked with 39 institutions (Figure 5). The community partners needed a variety of help: food, school materials, clothes, medicines, equipment, toys, books, computers, assistance repairing their buildings, and so on. They presented their needs in a format of themes of projects. Consequently the project scopes ranged from simple to complex. Nine of the community partners were responsible for 65% of all projects.

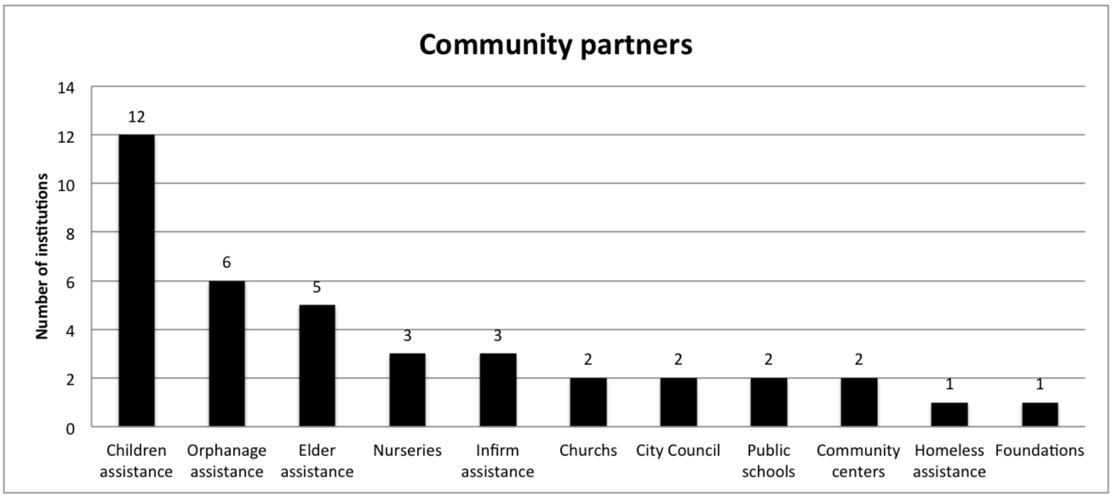

Figure 5. Community partners' main activities

ANALYSIS AND DISCUSSION

Due to our efforts to systematically building partnerships (Figure 2, Loop "Building Partnerships") there was a steady growth in the the number of community partners (Figure 5). The diversity of project's themes offered to the students (Figure 4), reflects the diversity of social work accomplished by our partners. In authors' opinion, it seems that the use of PBL techniques in addition to the improvement of educational resourses lead to the increase of student's enthusiasm with the course (Figure 2, loops "Professor's morale and "Students' morale").

Our findings suggest the students enthusiasm has relationship with the complexity of projects chosen. The students had freedom to choose the project themes. They could choose projects of complex, medium or easy scope. It was clear to us that highly motivated students tend to choose complex projects. That as the case in 10,5% of the projects. The majority of students chose projects of medium complexity (77,5%), a project adequate to the amount of time they have to work on it. Few students chose the easiest way, simple projects that didn't require a lot of effort. That happened in 12% of the projects. The previous theoretical knowledgement of project management techniques certainly was one of the factors responsible for the high success rate (82,5%).

CONCLUSIONS

The use of Project Based Learning supported by System Thinking proved to be a very useful course management method. The sum of the three systemic interventions we did brought the desired results. The relationships with community partners brought exciting project themes to the students. We think this contributed to increase of their motivation.

The choice of challenging the students to work with Community Partners that help poor and disadvantaged people brought additional benefits. Students became more aware about social responsibility and became more interested in making a contribution to the people that need it most. As we reflect on our efforts for well over a decade in more than 47 courses, we hope that our insights can serve a much broader audience.

For further information about the academic projects, there is a short documentary available in www.projectbasedlearning.com.br

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Creating a Project-Based Learning Environment to Improve Project Management Skills of Graduate Students

Joao Alberto Arantes do Amaral, Paulo Gonçalves, Aurélio Hess *

ABSTRACT

This article describes the project-based learning environment created to support project management graduate courses. The paper will focus on the learning context and procedures followed for 13 years, in 47 project-based learning MBA courses, involving approximately 1.400 students and 34 community partners.

Keywords: Project-Based Learning, Project Management, Education

INTRODUCTION

From 2002 to 2014 the first author taught Project Simulation, a course that is the final requirement for completion of the MBA degree in Project Management at the University of São Paulo, Brazil. During the course the students reviewed the basic theoretical concepts related to project management. They then learned how to make a project plan, studied project execution and learned control techniques. They also learned how to go about obtaining project funding, how to manage a project's risks and how to assure project quality. In this course they had the opportunity to put into practice the theory that they had learned in their previous studies.

In the course, the students were challenged to solve real-world problems brought by NGOs and Public Institutions (hereafter, Clients) that work to give assistance to poor and disadvantaged Brazilians.

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THE LEARNING CONTEXT

The classes were held in regular classrooms, using basic educational tools such as data show, the Internet connection, a whiteboard, removable chairs and desks. The students also worked outside the classroom - in their homes, in clients' facilities, or elsewhere. The key actors in the learning environment were the student teams, the clients and the professor (Figure 1). They interacted intensively each other during all project phases.

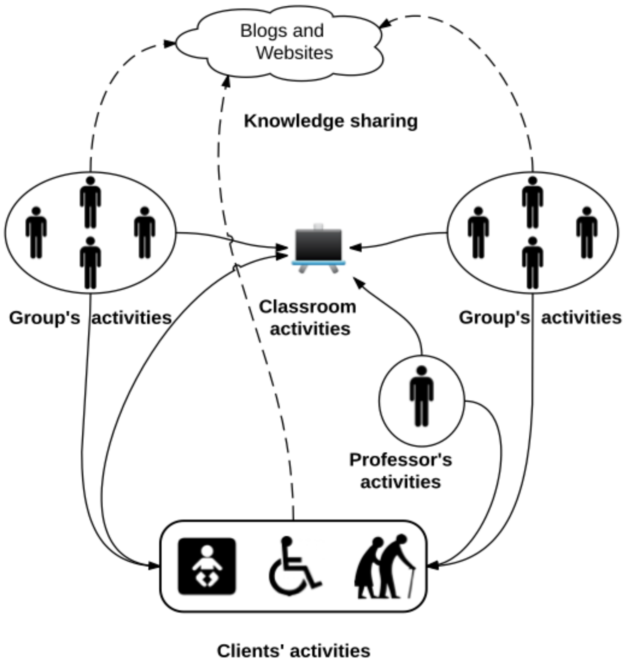

Figure 1. The course environment overview

The students

The majority of students held undergraduate degrees in Engineering, Management or Information Technology and had had at least five years of work experience. These graduate students worked in teams of 3 to 5 individuals. All had background in project management theory. The teams worked like real-life project teams: each member had a role and specific responsibilities. Each team had one project manager.

The clients

The clients were NGOs and institutions that work to help the poor and disadvantaged (Figure 2 and Figure 3). These organizations work with orphans, teenagers, elders, and children with non-contagious diseases or physical deficiencies.

Fifteen of the NGOs provide educational assistance, professional training courses, food and recreational activities to children from poor neighborhoods. Some of them also work with children who have suffered physical and sexual violence. Four are orphanages or work directly with orphanages, providing assistance such as school materials, food and furniture Four institutions help teenagers from poor families that live in drug-dominated city areas. They offer professional courses and job opportunities. Three work with elders who have been abandoned by their families, providing them food, clothing, medicine and recreational activities. Two institutions work with children with cancer and other non-contagious diseases or disabilities.

The majority of institutions that the students worked with do not receive any governmental help. They obtain the resources they need from donations and from the selling of products and services. The clients therefore needed a variety of help: food, school materials, clothes, medicines, equipment, toys, books, computers, assistance repairing their buildings, and so on. They presented their needs in a format of themes of projects. Each client was encouraged to present their real needs to students. Consequently the project scopes ranged from simple to complex.

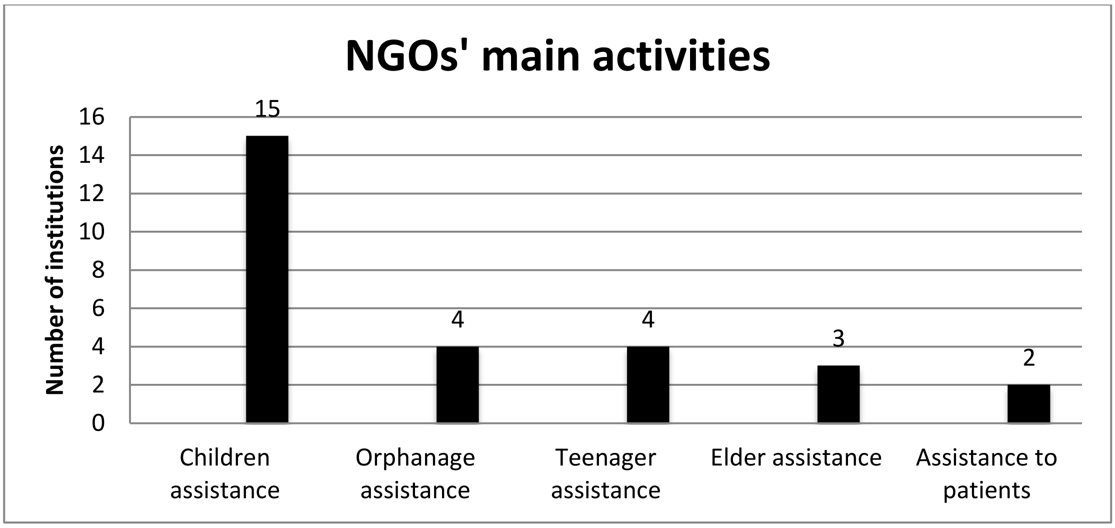

Figure 2. The main NGOs activities

In addition to NGOs, the students have worked with Public Institutions (City Counties, Public Schools, Public Hospitals and Community Centers), (Figure 3).

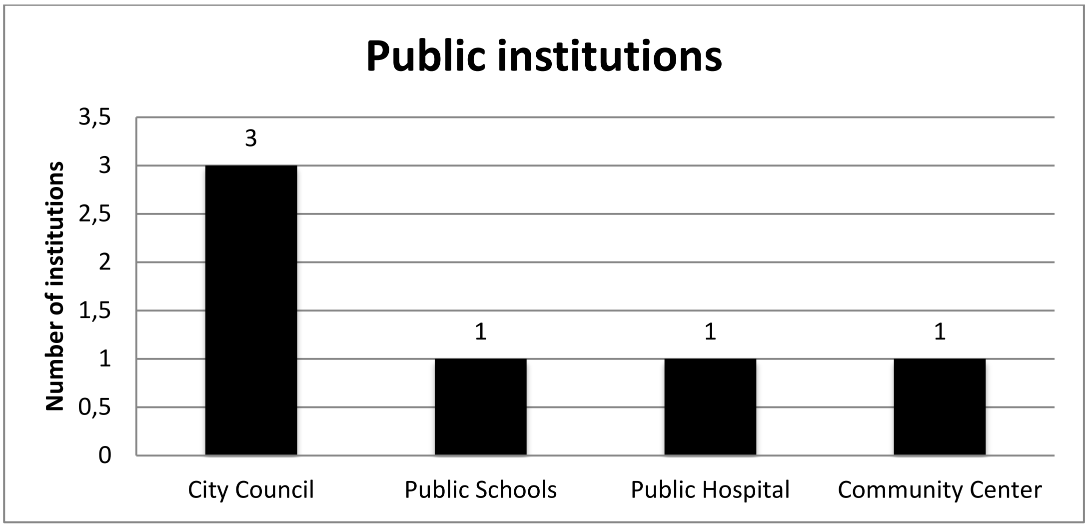

Figure 3. The main Public Institutions activities

The projects proposed by City Counties were related to website development and assistance in project planning. Hospitals proposed projects that involved helping them with hemophiliac patients. Public schools proposed projects related to small reforms and equipment acquisitions.

The professor

The professor has background in project management. He acted as instructor and program coordinator: he was responsible for seeing that the teams and clients worked in harmony. He was also responsible for managing the network of the clients.

Classroom activities

Each class met for three hours. In the first half of the class the professor gave a lecture about system dynamics techniques applied to project management. The students used the second half of the class to develop the projects and later report on them.

Group activities

Outside of class hours, the students had freedom to choose where to work, when to work and how to work. Usually they visited the clients facilities at the beginning of the project, in order to better understand the clients' requirements. During the project they intensively exchange information with clients.

Many of the project activities involved fundraising. The students obtained the necessary resources in a variety of ways: by seeking donations from corporations, selling raffle tickets, organizing fundraising events (like workshops and parties), soliciting donations from people of their social networks, and so on.

Clients' activities

The clients worked closely with the professor during the course preparation, presenting themes suitable for academic projects. They inspired the students with short presentations at the first day of class, when they presented the history of their institution, their achievements and their needs. During the project, clients tried to meet the students' requests as quickly as possible in order to avoid project delays. They also came to the final day of class in order to give feedback to the students about their performance.

Knowledge sharing

The students were required to create a blog for their projects. The blogs brought together all project information: plans, schedule, lessons learned, photos, videos and all other relevant information. The course combined traditional instruction techniques with intensive use of information technology.

THE PEDAGOGICAL FRAMEWORK

Problem-based learning (PBL) is an educational approach derived from the constructivist theory. According to Savery (2006, p.12):

> PBL is an instructional (and curricular) leaner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem.

Barrows (1996) emphasizes PBL's main features: teaching is centered on the learner, the learning takes place in small groups of students, teachers act as guides (or facilitators), the problems serve as a stimulus for learning and new information is acquired through self-directed learning.

The use of PBL techniques is not new. Markham (2003) reports that for more than 100 years educators (such as John Dewey) have the benefits of having students learn through performing practical projects. In United States, the problem-based learning has been used for years in schools, from elementary school to universities (Torp & Sage, 1998).
The concept of project-based learning is very similar to problem-based learning, but there are some conceptual differences. According to Savery (2006, p.16) in problem-based learning the learning activities are organized around achieving a shared goal (project). Markam et. al (2003, p.4) defines project-based learning as:

> Systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks

Project-based learning is suitable when the students are working in teams in order to create a product or service within a limited amount of time. In our experiment, the students were provided with project's themes (specifications of a final product or service to be created) and were oriented to follow well defined projects' phases.

Problem and project based learning is becoming increasingly relevant in today's world. Bell (2010) suggests that the use of these teaching methods enable students to develop key skills such as collaborative working, capacity and ability to solve complex problems. Nowadays some universities make use of problem and project-based learning in their courses (Barge, 2010) (Fredhom et. al., 2002), such the University of Aalborg (Denmark) and the Olin College (United States).

Some authors (Larmer, Mergendoller, 2010), (Thomas, Mergendoller, Michaelson, 1999) point out the essentials elements of project based learning as follows. They must have a significant content, develop in students 21st century competencies, allow in-depth inquiry and include driving questions. In addition, students should learn during the project and be able to exercise their voice to make choices, the process itself should involve critique and revision, and should have a public audience beyond the students and professor.

In our experiment we pursue those essential elements. We though that in order to become better project management professionals, the students should have not only theoretical experience, but practical experience as well. The project-based learning was the way of achieving it.

THE PBL EXPERIENCE

The PBL experience was carried out from 2002 to 2014, in a sequence of 47 courses.
Each course had twelve lectures. The experience followed sequence of activities described in Figure 4.

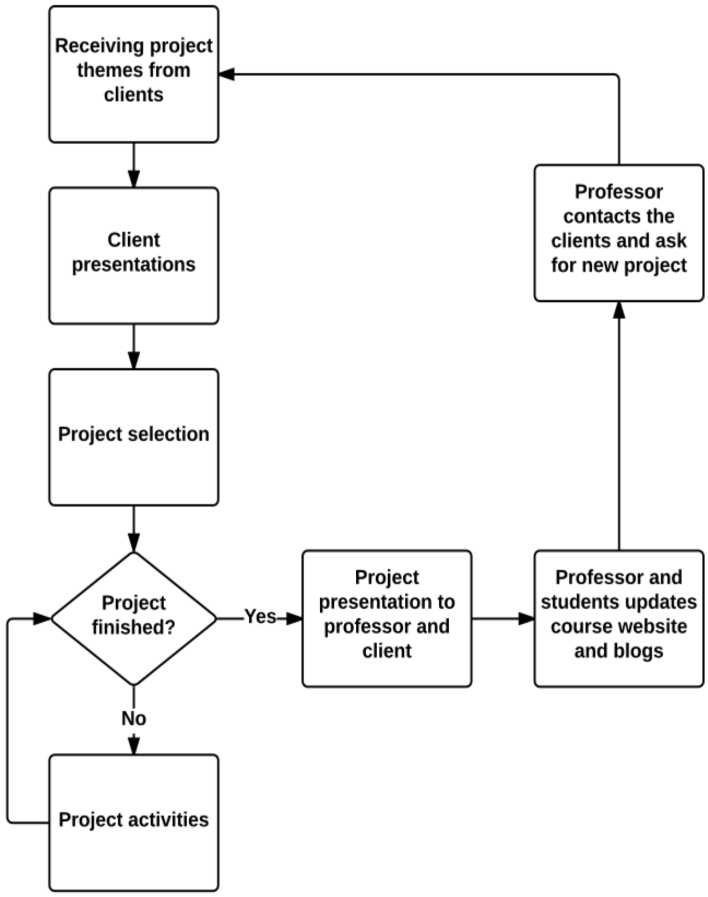

Figure 4. The course activities flowchart

The professor contacted the clients one week before the first day of class, in order to receive the projects' themes from their institutions. The clients sent the themes and the professor updated the course website. The first class was very important to both students and clients: the clients provided more than information, they gave motivation and inspiration to the students. Motivation is a key issue in Project Based Learning, as it inspires students to work hard to overcome the difficulties.

Moreover, the feeling of working on a socially relevant project, one that will bring benefits to community, touched the students deeply.

The face to face contact with clients at the first meeting was also important, for it invigorated the clients, improving their willingness to work with the students. After this meeting the students had one week to choose a project from a theme list available on the course website.

The project then began; students were involved in project activities right up to the final day of course. The final class was also a landmark. The students presented the achievements of the project, and reported on the main lessons learned. They received feedback from both the professor and the clients.

RESULTS AND REFLECTIONS

Reflecting about the experiment, it was clear to us that it brought educational benefits to all involved and material benefits to the community. Thinking about the educational benefits, we asked ourselves if the courses addressed the essentials of the project-based learning. We guess that one good way of making our reflection useful to the wider community of PBL researchers and practitioners is confronting what we achieved with the essentials of project-based learning.

1. Did our courses have driving questions?

Yes, there were two tacit driving questions in Project Simulation course:

- What has to be done in order to deliver, in twelve weeks, the product or service that the client needs?
- How can it be done, working in a project team structure?

The first driving question has to do with strategy and planning. The second is related to execution and control. The project management activities brought the answer to the two driving questions.

2. Did the course bring significant content to the students?

The Project Simulation course worked as a project management laboratory. In the laboratory the students had the opportunity to develop skills based on theory they have learned previously. For example, in previous disciplines they studied how to create a plan. In the course they had the opportunity not only to create a plan, but also to execute it. Planning and re-planning, working and reworking, are all parts of the learning process. During the project the students had the opportunity to figure out solutions to the problem that they faced. They learned from their successes and from their failures. The course content was significant to students because it gave them the responsibility of solving real life problems, similar to those that they will face in organizations where they work.

3. Did the students develop 21st Century Competencies?

In order to accomplish the projects, the students developed competencies of today's world: they were be able to collaborate and communicate using modern computational resources and tools. Most of students worked during the day and attended the MBA course at night. In other words, they had limited available time to devote to the project. In order to work more effectively, the students made intensive use of internet-based collaborative software. They also were very creative in finding solutions to the problems that they faced.

The majority of projects involved fundraising. The students developed several strategies to obtain the necessary funds, including soliciting resources from their social network, requesting donations from companies, organizing fundraising workshops, and so on.
One important competency of the modern manager is the ability to manage conflicts. The students faced several kinds of conflicts, including between team members, between the team and the client, and between the team and the professor. Sometimes the students disagreed each other about the management process to follow, sometimes the students and the clients had different opinions about the better way of accomplish the project. Conflict management was thus an essential part of the learning.

Another important competency project managers should have is the ability of manage the changes in project's scope. Sometimes the client changed his or her mind during the project, asking more than what was agreed upon at the beginning of the project. The students were thus obliged to put into practice scope management theory in order to accomplish the project successfully.

4. Did we allow in-depth inquiry?

The in-depth inquiry was present in the academic projects in several ways. In every class the professor challenged the teams with project management related questions. He asked the students about the strategies that they had chosen and the management process they followed. Every week they discussed the decisions taken and their direct and indirect effects and consequences. For example, sometimes when they discussed possible changes in the project's scope, they did an in-depth inquiry of the possible consequences in terms of project's costs, schedule and product's quality.

The students also questioned the professor about relationship between the theory they studied in previous project management courses and the practical use of this theory in the real-life project. The students questioned the clients about their needs, and questioned themselves about effective ways of solving the problems they faced.

5. Did the students gain knowledge during the project?

As the projects moved forward, the students felt the need to know more about socially-related projects. The majority of students had never worked with NGOs. The students usually worked for corporations or for the government. Socially-related projects were a new experience for almost all of them.

In order to accomplish the project with NGOs the students had to learn the basic organizational structure of the clients' institutions, their processes, their needs and expectations. Every project brought the students new learning opportunities, since they were working in areas with which they had had no prior experience.

6. Did we allow the students to have voice and choice?

At the beginning of the project, the students chose a project from the project theme list. Usually we worked with ten clients in each course and each client presented at least seven projects. Hence, the students might choose a project theme among 70 project themes. During the project they were totally free to choose the team structure, the team member roles, the management tools to be used, and the plans to create. The professor did not interfere in the decision process.

7. Were there critique and revision processes?

Every week the students did a short project status presentation to all other students and the professor. The process of critique and revision was clearly defined. After each team made his presentation, the professor chose specific points to critique. The critique was made with the objective of bringing improvements to the project and to the learning. Moreover, all other teams were also invited to critique the project of their peers. This proved to be an excellent way of knowledge sharing. The best management solutions were shared with all participants. Each group could observe the development of other groups. Those groups whose performance was below the average became motivated to increase their efforts in order to keep up with the leading teams.

8. Were the projects presented to public audience?

At the last class of each course the project were presented to all the community partners. Sometimes the projects were also presented to other professors, interested in the methodology and the results.

The projects also brought several material benefits to the community partners and to the to poor and disadvantaged people.

We estimate that, in average, each project had raised about 2,500.00 (two thousand and five hundred dollars) in genres, products and services. So, conservatively, it can be estimated that the projects have led to resources on the order of half million dollars.

CONCLUSION

We hope this article contributes to disseminate a practice that worked quite well for many years. We expect this experience would inspire other professors that work in similar context.

For further information about the academic projects, there is a short documentary available in www.projectbasedlearning.com.br

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