Adoption of a New Project-Based Learning (PBL) Curriculum in Information Technology

P Vesikivi
Principal lecturer
Helsinki Metropolia University of Applied Sciences
Helsinki, Finland
E-mail: petri.vesikivi@metropolia.fi

P Hjort
Senior lecturer
Helsinki Metropolia University of Applied Sciences
Helsinki, Finland
E-mail: peter.hjort@metropolia.fi

M Lakkala
Post-doctoral researcher
University of Helsinki
E-mail: minna.lakkala@helsinki.fi

J Holvikivi[1]
Principal lecturer
Helsinki Metropolia University of Applied Sciences
Helsinki, Finland
E-mail: jaana.holvikivi@metropolia.fi

Keywords: Problem-based learning, curriculum development

INTRODUCTION

This paper presents early findings of the curriculum reform in engineering education in the Metropolia UAS. A large-scale reform in curricula was launched in August 2014, in order to address low retention in engineering studies. The aim was to enhance education by applying collaborative project based learning models through the whole university. In the information technology degree programme, first year studies were integrated into four thematic 15 ECTS modules of eight study weeks. This paper focuses on the first experiences of the curriculum change, in particular retention rate, as well as student and teacher satisfaction evaluated through online questionnaires. Analysis of first year study results indicate that the new approach has helped students to keep up with the planned pace of study. Further more their

[1]Corresponding Author
J Holvikivi
jaana.holvikivi@metropolia.fi

comments as well as teacher comments were more in the positive/successful than in the negative/non-successful category.

1 BACKGROUND

1.1 Collaborative problem solving and project-based learning

Problem-based learning, inquiry-based learning, project-led learning, and project-based learning have been applied and debated already for decennia [1]. The distinction between these terms is not clear-cut. Project-based learning, in particular, has been used in engineering education, as it follows professional practices in the field and, therefore, appears as a natural mode for studies.

One of the well-known systematic efforts towards project-based learning is the global CDIO initiative that has united a number of engineering institutions around a common curriculum structure, including several Finnish universities [2]. Another global model which extends beyond engineering is led by the Aalborg University in Denmark [3]. Kolmos [4] has compared these two models and finds them to be mutually complementary rather than competing. The CDIO model includes one project in each academic year, whereas the PjBL model followed in Aalborg is totally based on thematic project courses. Numerous other implementations of project-based learning methods have been reported in various countries in recent years [5 - 9], just to mention a few.

In the CDIO syllabus, personal, professional, and interpersonal skills include engineering reasoning and problem-solving, experimentation and knowledge discovery, system thinking, multidisciplinary teamwork, and communication [2]. Collaborative problem-solving and project-based learning simulate challenges that the students will face in their professional work, such as open ended assignments, uncertainty and coordination of collaborative efforts. Learning takes place between members of the collaborative community, and it is indistinguishable from practice [10]. In this study, we assumed that it is most efficient to start with open-ended problems immediately at the beginning of studies.

1.2 Aims of the study

At the Metropolia UAS, the studies in IT were previously loosely structured. The incoming groups started with short courses in mathematics, physics, and the basics of information technology or media technology. Most courses were from 3 to 5 ECTS credits, and consisted of lectures to a large audience and laboratory practice for groups of 24 students. If students failed the courses, they could retake them during the following academic years. Unfortunately, this freedom and independence did not result in good retention, to the contrary: nearly 40 % of students interrupted their studies already after the first year and only 40-49 % graduated in 5 years (see *Table 1*). Interrupting studies is quite common in Finland where higher education is free. However, the high dropout rate was costly for the university, causing big losses of income from the government, which gives funding for ECTS credits and graduates.

Table 1. Retention at Metropolia UAS in Engineering.

2009	2010	2011	2012	2013
42 %	40 %	43 %	45 %	49 %

The main aim of this study was to investigate how a curriculum, which is based on project-based learning, impacts the amount of students who complete all compulsory

courses during the autumn 2014. Another aim was to examine how students describe their learning experiences and outcomes, and how teachers evaluate the success of new pedagogical practices. The results of the study will be used as a basis for planning courses for the next academic year.

The questions addressed in this study are the following: What is the impact of integrated 15 ECTS credit models on the student course completion rate in comparison to previous curricula? Did the dropout rate change and how from previous years? How do the students and teachers evaluate the benefits and challenges of the course practices?

2 METHODS

2.1 Setting and participants

According to the system that was introduced in autumn 2014, students were divided into groups of 25-30 students and they studied together from 9 a.m. to 4 p.m., five days a week. Presence was declared compulsory, even though it was not very strictly controlled. However, regular presentation sessions forced students to be present also in practice.

Information technology students were divided into groups of approximately 30 individuals and altogether 10 groups in two campus locations were formed. This study focuses on students in Leppävaara campus: all in all 116 students began their studies in the Finnish degree programme (four groups) and 44 students in the international degree programme (two groups). Each group studied in the same theme classroom throughout the period. A team of lecturers representing different professional disciplines such as communication skills, mathematics, physics, programming and electronics instructed them. Students in the study programmes came from different backgrounds: some of them had already a bachelor's degree in some other field and some had completed a vocational school. However, the largest part had completed high school. International programme students came from various countries, the majority from Vietnam and Nepal.

Starting from autumn 2014, first year studies were divided into five 15 ECTS courses: Orientation, Networks, Robots, Games and Objects. Each course lasted for eight weeks out of which the last week was reserved for resit exams and getting unfinished assignments completed. The student groups took all the courses, except for the Orientation course, in different order. Because of this, the courses were generally designed as independent modules that did not rely on students having previous knowledge about the course topics. Only mathematics and physics were taught in a systematic order throughout the academic year. In this paper experiences gained in the first two periods are analysed.

Students in the international programme had to participate in Orientation, Networks, Robots and Games courses, whereas students studying in the Finnish programme took the Objects course instead of the Orientation course. The Orientation course in the very first study period aimed at giving international students a good understanding of information technology basics, as well as enhancing independent learning skills and adopting academic practices. Also, the students learned teamworking skills and project management while completing course assignments. The Objects course focused on object-oriented programing using Java programming language and it was built around a project where students designed and programmed a Lego Mindstorms robot. The Networks course introduced students to basic data communication and network security. Instead of a single eight-week project, students did shorter projects on networking and internet security. The Robots course focused on digital technology and embedded

systems. During the course students modified Python application software designed for a robot. On the Games course students created a text-based adventure game using Java and object oriented design principles. All courses included physics and maths as well as media related topics (web development, video production, photography, 3D modelling) and either Finnish or English communication.

All classrooms had flexible furniture arrangements, small tables and whiteboards that could be moved around. There were some fixed computer workstations in addition to student laptops. Mostly students were using their own personal laptops. All classes for one group were held in the same classroom for the seven-week period. In case someone was unable to attend the classes, other team members were encouraged to share information and progress on project work via social media.

2.2 Cumulated ECTS credits

Cumulated study ECTS credits were fetched from the study register on 17 March 2015. For students who started their studies autumn 2014, ECTS credits registered by 1 March 2015. A similar time window was used for students who started their studies in autumn 2012 and 2013. The data were filtered to include only enrolled students, and identification information was removed from the data. ECTS credits from eventual previous work placements were also removed. In the data set, the four Finnish and two international study groups were combined into a single sheet. During academic years 2012-2013 and 2013-2014, the School of IT at Metropolia had four study programmes: international and Finnish IT programmes as well as international and Finnish Media programmes. Thus, in the final data set there were six sheets: 2012-2014 international study programmes, and 2012-2014 Finnish study programmes.

2.3 Course feedback

After each course, student and teacher opinions and experiences from the courses were collected through an online questionnaire as part of the KNORK project (http://knork.info) supported by European Commission. The answers to two open questions concerning positive/successful and negative/non-successful aspects were used as data in this study. In all, 100 answers from students and 18 answers from teachers on 12 courses were received. The answers were analysed using a data-driven thematic analysis method [11]. The following main content categories were constructed and used in the final analysis for categorizing both positive and negative aspects of the courses mentioned by the participants: Facilities, Organisation, Content, Teaching and Guidance, Working methods, and Outcomes. In all, 275 statements were selected and coded from the student answers and 59 from the teacher answers.

3 RESULTS

3.1 Student retention

The ECTS credit accumulation was investigated by examining students who stayed on track with their studies meaning they achieved 60 ECTS minimum during one academic year. For the first two periods (out of four) the percentage of students who completed 30 ECTS credits or more increased in both the Finnish and international programme (Tables 2 and 3).

Table 2. Metropolia UAS Finnish study groups

	2012, n=143	2013, n=149	2014, n=106
1-14 ECTS credits	14%	11%	0%
15-29 ECTS credits	26%	41%	14%
30->	59%	48%	86%

Table 3. Metropolia UAS international study groups

	2012, n=74	2013, n=76	2014, n=35
1-14 ECTS credits	23%	14%	0%
15-29 ECTS credits	46%	68%	20%
30->	31%	17%	80%

Although *Table 2* and *Table 3* represent a significant increase in retention, we cannot ignore the fact that less students were admitted in 2014 compared with years 2012 and 2013. In 2014 Metropolia UAS had 44 international programme students whereas in 2013 and 2012 there were 90 and 92 students respectively. All in all, in 2014 there were 116 first-year students in the Finnish programme, compared with 184 and 162 first-year students in the academic years 2013 and 2012 respectively. As fewer students were admitted, it is possible that those who started studying in autumn 2014 could be more academically oriented resulting more students achieving 60 ECTS credits during the first term.

However, if we examine the absolute amount of students who completed 30 ECTS credits or more during the first two periods, i.e. are on track in their studies, we can see that the introduction of courses adopting new project-based learning approach increased the number of students on track from 23 (2012) and 13 (2013) to 28 (2014) in the international programme and from 84 (2012) and 72 (2013) to 100 (2014) in the Finnish programme. Students who had zero ECTS credits during the autumn term were omitted from the analysis, because the underlying reasons for the poor performance were often found to be related to students' personal lives.

Fig. 1-3 show the ECTS credits accumulation sorted by the number of ECTS credits (For these figures the ECTS credits earned by those studying in the international and in the Finnish program were combined to form a single data set.). From these figures one may conclude that the changed mode of teaching had a considerable effect on the number of students who were on track with their studies. In the new curriculum (2014), more students could potentially be kept "on board" during and after the first semester than in the old curriculum (years 2012 and 2013).

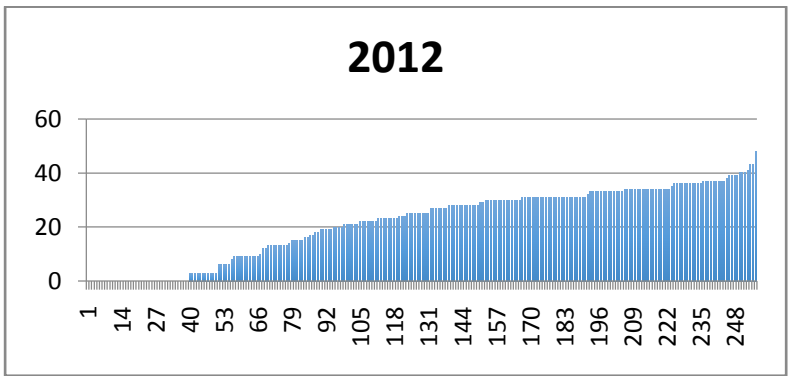

Fig.1. Cumulated credits per student autumn semester 2012

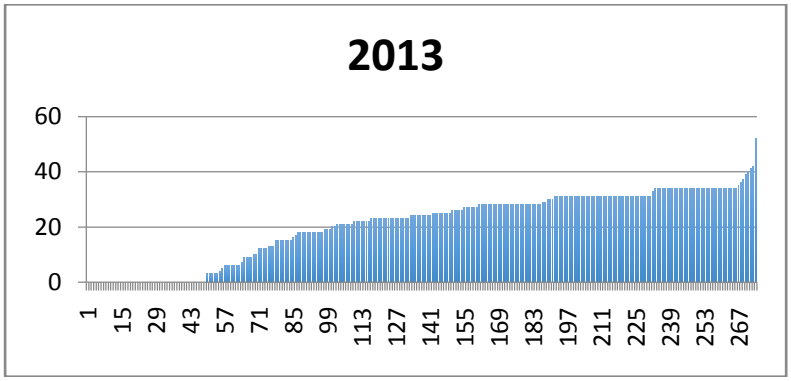

*Fig.2.*Cumulated credits per student autumn semester 2013

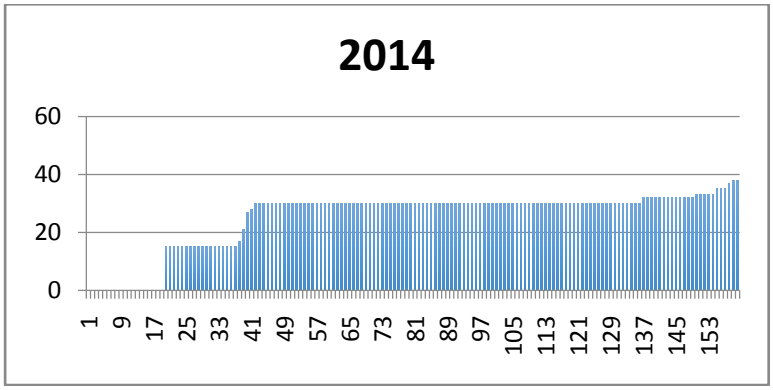

Fig.3. Cumulated credits per student autumn semester 2014

3.2 Student and teacher evaluation of the course

In the student answers to the feedback questionnaire, 149 statements were coded to include a positive evaluation, and 135 statements were analysed to address challenges or disturbances.

The following aspects received positive feedback by students:

- *Working methods* (61): Practical tasks (17), Group work (19), Learning community and atmosphere (14), Working methods in general (7), Project work (2), Freedom of choice (2);
- *Teaching and guidance* (35): Good teachers and teaching (22), Teachers' positive attitude (5), Guidance and feedback from teachers (8);
- *Outcomes* (19): Learnt new things (14), High quality products (5);

- *Content* (18): Interesting and useful content (18);
- *Organisation* (12): Good entity (7), Appropriate phase of work (3); Good integration of subjects (2);
- *Facilities* (4): Good study premises and equipment (4).

The following issues were mentioned by students in negative terms in the course feedback:

- *Organisation* (43): Uneven workload (9), Confusing and incomplete arrangements (12), Poor integration of subjects (8), Tight timetable and heavy workload (7), Poor communication practices (7);
- *Working methods* (40): Problems in group work (13), Too little teaching of theory (8), Challenging working methods (6), Restless classroom (4), Too much group work (4), Too much teaching of theory (3), Compulsory attendance (2);
- *Content* (27): Difficult content (18), Not interesting or useful content (9);
- *Teaching and guidance* (19): Poor teachers and teaching (7), Too little guidance and feedback (6), Unclear goals and evaluation criteria (6);
- *Facilities* (7): Inadequate premises and equipment (7).

In the teacher feedbacks, 36 statements evaluated the courses as positive or successful, whereas 23 brought up negative or unsuccessful aspects.

The following issues were mentioned by the teachers as positive or successful:

- *Outcomes* (22): Successful products and task results (7), Active and committed students (7), Students learnt working skills (4), Students learnt new content (4);
- *Working methods* (8): Students' group work (4), Teachers' interaction with students (2); Intensive working period (1), Fixed classroom (1);
- *Organisation* (5): Well-working timetable (2), Smooth teacher collaboration (2), Good integration of subjects (1);
- *Teaching and guidance* (1): Good teaching (1);
- *Facilities* (1): Good equipment (1).

The following aspects were mentioned by teachers as negative or unsuccessful in their course evaluations:

- *Organisation* (12): Problems with the timetable (4), Weak teacher collaboration (2); Integration of transfer students (1);
- *Facilities* (5): Inadequate premises and equipment (5);
- *Working methods* (4): Problems in group work (2), Too little traditional teaching (2);
- *Outcomes* (2): Poor study success (1); Students were passive or absent (1).

4 CONCLUSION

Early conclusions of the curricula reform at Metropolia UAS are very satisfactory, not only when considering the increased retention rate but also the number of students who completed their courses as planned. Student feedback on the working methods as well as teaching and guidance during the courses were viewed as positive. These results seem to indicate that the chosen method, project-based learning, works well with first-year students.

There was also some critical feedback from students, including the following: student workload should be divided more evenly during the course, difficult subject matter, and shortcomings in integrating different subjects. Also the teachers mainly mentioned issues related to course organization as unsuccessful aspects in the

courses.The feedback reflects the fact that all the courses were held for the first time. In addition, many teachers were not used to co-teaching.

This study was based on the two first periods of the first study year. Comparison of results of different implementations will give suggestions on how to best continue the integration of study subjects. In order to get a more comprehensive understanding of the effects of the curriculum change, data collection will need to include the whole first study year and possibly continue until graduation.

REFERENCES

[1] Blumenfeld PC, Soloway E, Ronald W. Marx RW, Joseph S. Krajcik JS, Mark Guzdial M and Palincsar A (1991), Motivating Project-Based Learning: Sustaining the Doing, Supporting the Learning, Educational Psychologist, Vol. 26, No 3-4, pp. 369-398.

[2] Crawley EF, Malmqvist J, Östlund S, and Brodeur DR (2007), Rethinking engineering education. The CDIO Approach, Springer, New York.

[3] Kolmos A, Krogh L, and Fink FK (2004), The Aalborg PBL model: progress, diversity and challenges, Aalborg University Press, Aalborg.

[4] Edström K and Kolmos A (2014), PBL and CDIO: complementary models for engineering education development. *European Journal of Engineering Education*, Vol. 39, No. 5, pp. 539-555.

[5] Macías-Guarasa J, Montero JM, San-Segundo R, Araujo A and Nieto-Taladriz O (2006), A Project-Based Learning Approach to Design Electronic Systems Curricula, *IEEE Transactions on Education*, Vol. 49, No. 3, pp. 389-397.

[6] Mantri A. (2014), Working towards a scalable model of problem-based learning instruction in undergraduate engineering education. *European Journal of Engineering Education.* Vol. 39, No.3, pp. 282-299.

[7] Lehmann M, Christensen P, Du X, andThrane M (2008), Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education, *European Journal of Engineering Education*, Vol. 33, No. 3, pp. 283-295.

[8] Macías-GuarasaJ, MonteroJ M, San-Segundo R, Araujo A and Nieto-Taladriz O (2006), A Project-Based Learning Approach to Design Electronic Systems Curricula,*IEEE Trans on Education*, Vol. 49, No. 3, pp. 389-397.

[9] Fernandes S, Mesquita D,Flores M and Lima R M (2014), Engaging students in learning: findings from a study of project-led education,*European Journal of Engineering Education,* Vol. 39, No. 1, pp. 55-67.

[10] Wenger E (1998), Communities of Practice: Learning, Meaning, and Identity, Cambridge University Press, Cambridge.

[11] Braun Vand Clarke V (2006), Using thematic analysis in psychology,*Qualitative Research in Psychology,* Vol. 3, No. 2, pp. 77-101.