EFFECTIVENESS OF PROJECT-BASED LEARNING IN GIS COURSE

Branko Blagojević
Marjan Sikora
Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture
Split
Croatia

ABSTRACT
Analyses and surveys at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB) showed that, after the application of the Bologna Process for engineering curriculum in 2006. and implementation of Croatian Qualification Framework Law (HKO) in 2013., the students still consider engineering studies to be 'too hard' and 'boring'. It is recognized that one of main reasons for such a description is teaching and learning approach, which is still based on classroom lectures and focused on teaching theories and technical knowledge. Project-based learning (PBL) as a teaching tool is used globally today as a more effective approach in engineering education. The paper presents an illustration of effectiveness of PBL on students' motivation through implementation on GIS course (Graphic Information System) on computer engineering study at FESB. Assessment and evaluation is done based on feedback from students and teachers. Conclusion points out the positive impact on students' motivation but also indicates some potential problems of PBL implementation in specific education environment, like one at FESB.

Keywords: engineering education, project-based learning, computer engineering study

1. INTRODUCTION

The statistics at Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture (FESB) in Split, shows that the number of student who finish their studies is very low, both at undergraduate and graduate level [1]. First deeper analysis showed that students' motivation on Naval Architecture studies (NA) at FESB is very low; they are not attracted to the courses and they consider teaching and learning approach inadequate for work in a real world [2]. The NA study is typical engineering study at University of Split and it was chosen for deeper analysis of students' motivation purely from practical reason - the lowest number of students. Further surveys showed that the students of other studies at FESB, computer engineering (CE), mechanical engineering (ME) and industrial engineering (IE), share the same opinion. It seems that students 'simply' lose their motivation for education and they give up their studies. This is enormous waste of time and resources, so the initiative to change teaching and learning methods at FESB has started at Naval Architecture (NA) studies in 2009. Positive experience with project-based learning, problem-based learning and the CDIO (Conceive-Design-Implement-Operate) approach [3, 4], gave incentive to teachers at computer engineering studies to try with implementation of project-based learning (PBL) in their courses. Increasing the motivation of computer engineering students is very important for FESB, since the number of students on CE studies is much higher than number of students at NA studies. On NA studies, it is up to 15 students on the last year of undergraduate study and on computer engineering studies these numbers are in hundreds. It was imperative to reduce drop-out on CE studies, not just to improve statistics, but it was also required by the industry, since computer engineers are the most wanted occupation in Croatia, according to the National employment statistics [5]. It was decided to test PBL approach on elective course Graphic Information System (GIS) on CE study. Since there is no standard to PBL approach, in contrast to the CDIO [6], it was necessary to adapt experience from teachers at NA studies at FESB as well as the experience and recommendations of many other educators to Croatian laws and specific working conditions at FESB [7, 8, 9, 10, 11]. These approaches show that students gain their necessary engineering knowledge, theoretical and technical, through practicing engineering rather than sitting in classrooms and listening (or watching presentations). It is primary task for the teachers to increase student's motivation by supporting various actions to adequately relate theoretical knowledge and facts with real-world engineering problems. Modern engineers should be able not only to apply technical content but also to work as members of professional and interdisciplinary teams and be able to communicate and collaborate on various levels. Current curriculum does not enable students to develop skills and abilities they need to keep up with the rapid progress, especially in the field of computer engineering.

The implementation of PBL and CDIO at NA study at FESB has been gradually changing to find the most appropriate approach for specific working, material and financial situation at FESB, which is quite similar to the most of engineering faculties in Croatia. It was expected that GIS course will also require adjustments, year after year, to find the most effective and efficient teaching and learning scheme, with the main goal to increase motivation of students. This paper presents the first two years of implementation of PBL on GIS course.

2. COURSE IMPLEMENTATION

GIS is elective course and expected number of students is between 30 and 40 every year, although there is no formal limit for number of enrolled students. The course was, from beginning, conceived as PBL course, in contrast to all other courses at computer engineering study at FESB, which are still conducted in traditional teaching approach. It was also a known fact that students who would enroll this course already got a lot of experience in traditional teaching and learning approach, so they should be able to compare GIS and other courses in surveys.

2.1. Course content and objectives

In this course, students are encouraged to increase their interests in design and development of geographic information systems and to learn how to apply their programming knowledge in designing GIS system. The content includes the historical overview and the current state of technology in GIS; types of spatial data; collecting and entering spatial data; 2D and 3D spatial data analysis; geographical projections in different scales; creation of topographic maps; design and development of local and web GIS system. After finishing the course student should acquire knowledge necessary for understanding the features of various types of spatial data and for the design and development of GIS systems as well as spatial data analysis.

2.2. Learning outcomes

Learning outcomes are defined in accordance with the Croatian Qualification Framework [12], which is based on Bloom's taxonomy [13] and recommendations institutions and organizations like ASIIN [14], ABET [15] and ENAEE [16]. Factual knowledge today becomes fast obsolete, and skills, like cooperation, communication, critical thinking, etc., become more and more important for modern engineers. By developing a PBL course where students have to work on solving project problems and present their ideas and solutions, they were able, not only to gain necessary technical knowledge in more motivating way than on traditional lectures, but they also had the opportunity to develop and practice various skills. Students who participated in group projects also benefited in developing team-work skills, collaboration and cooperation skills and leadership. All of them had the opportunity to develop, probably the most important skill: how to learn, since in order to solve project problems they had first to learn basics and then to advance in their knowledge by finding and reading literature and sharing that knowledge, first within their group, and later with other students and teachers.

2.3. Course preparation and student activities

Based on the experience from NA studies it was decided to split students into groups of 3 to 5 students. They were introduced with the default spatial topic. For example, a project space was the historical core of the city of Split. The students were introduced to some possible projects within the given space, for example GIS ATM, GIS parking, terrain and 3D models of buildings in the centre, etc. After the introductory lecture they were given the opportunity to form groups (teams) and each team had to choose one project, but under the following conditions:

- The project should be linked to the default spatial topic for that year.
- The project should include input spatial data with paper maps and / or GPS units.
- The use and processing of existing spatial data from GIS database and / or publicly available data such as WMS layers.

Also, the students could suggest a new project idea and teachers had to decide whether this new project requires the similar amount of work and time as all the other project themes. The results of each project had to be a map on paper and distributed GIS system. Groups could choose their own software tools to work, tools for measuring spatial data, content, and map design, architecture of distributed GIS.
Special emphasis was on keeping the deadlines for individual stages or delivery, which were:

- Project plan - students briefly present a project description, methodology (choice of software, devices for data collection, etc.), the schedule of the project and the distribution of work to team members.
- Input data report - students present one part of the data model, sampling, report the work in the field and for the information already provided a description of the data source.
- Final Report - all previous reports and description of the spatial analysis, a description of distributed GIS, detailed records of all members of the group and grade proposal for each group member.

All reports were presented in front of a group of teachers and students. The presentations, which included discussions with teachers and peers, were part of the assessment scheme of groups and individual students. Student activities included reading literature, communication with teachers and peers, team-work and meetings with discussions on project problems. The main activities of the course:

- Introductory lecture (3 hours). Students were divided into groups and presented with project ideas. Afterwards they formed groups, without teachers influence, and chose the theme for the project.
- There was no mandatory software for GIS and the students could choose themselves which software to use.
- Format for reports was not defined. It was up to students to find the most appropriate

way to present their work.
- Students were able to report their work as soon as they finished, i.e. they did not have to wait until the end of the semester for the final report.
- Some students had asked to not to participate in projects, so they were offered individual tasks. They presented the results of these tasks to teachers and other students, but did not participate in team-work (not part of the learning outcomes).

3. ASSESSMENT

Assessment and grades is one of the main problems in PBL approach in contrast to traditional approach, where grading is simple based on the results of the tests (exams). In PBL it requires more effort from teachers, since all the student activities have to measured somehow. It is relatively simple to track their progress when number of students per teacher is small, up to 10 from experience at FESB and if there is only one joint project for all students (NA study). For courses with more students, like GIS, there are more groups with similar, but still different projects and assessment becomes a demanding (additional) work for teachers. It is recommended to set up some grading model, so that students know which activities are "more important" i.e. which activities directly influence a grade. Teacher also has to explain to students that additional activities are also part of the final grade, for example additional reading and research. In this course, there were two "types" of students: students who worked in groups (participated in group projects), and students who preferred individual work. In either case students had to present project plan (PP), report about input data (IUP), GIS map (K), distributed GIS (DG) and final report (ZI). In each case, they had to present final report in front of the teachers and students. The quality of their work was assessed by teachers, but also from their peers through discussion and assessment tables. Final grade was determined as:

Grade (%) = 0,3 DG + 0,3 K + 0,15 PR + 0,15 ZI + 0,05 PP + 0,05 IUP

Table 1. Grades for the first two years in GIS course

Year	Number of students	Grade				Number of groups
		(5) - highest	(4)	(3)	(2)	
2013/14	24	11 (46%)	9 (38%)	4 (17%)	-	6
2014/15	47	21 (45%)	19 (40%)	5 (11%)	2 (4%)	12

4. SURVEYS AND COURSE EFFECTIVENESS ASSESSMENT

Comprehensive surveys, of more than 20 questions, among students were done using online anonymous survey tools each year. The most significant and interesting questions and answers, regarding PBL effectiveness, are presented in following tables.

Table 2. Survey question 1

Theoretical and practical technical knowledge	2013/14	2014/15
- can be learned better in traditional teaching approach	3%	9%
- can be learned better in PBL teaching approach	73%	45%
- teaching approach has no influence on learning	24%	45%
Teacher's comment: students prefer PBL approach, but there is a negative trend. It seems, from discussions with students, that the main reason is project theme attractiveness, since nothing else has changed.		

Table 3. Survey question 2

We were more interested in topic (i.e. motivated to learn GIS):	2013/14	2014/15
- when traditional teaching is used	3%	0%
- motivation is the same regardless of teaching approach	6%	36%
- when PBL approach is used	91%	64%
Teacher's comment: students prefer PBL, but there is negative trend here too, also probably due to less interesting theme in the second year.		

Table 4. Survey question 3

Assessment and grading is more fair and clear:	2013/14	2014/15
- on traditional course	12%	36%
- is the same on traditional and PBL course	64%	45%
- on PBL course	24%	18%
Teacher's comment: assessment and grading scheme had not changed, so there are other, probably personal factors, influencing answers.		

Table 5. Survey question 4

Workload is (compared to the work-hours resulting from course's ECTS points):	2013/14	2014/15
- higher on traditional course	34%	45%
- equal on traditional course and PBL course	63%	45%
- higher on PBL course	3%	10%
Teacher's comment: Students consider workload is smaller on PBL course. However, from teachers' evidence the students have been using labs and classrooms more often. It seems they simply do not consider the learning and working on interesting project so demanding and they "forget" that they have actually spent more hours in the university labs and classrooms.		

Table 6. Survey question 5

Which knowledge and skills do you consider more important for future work?	2013/14	2014/15
- those obtained on traditional course	3%	0%
- those obtained on PBL course	94%	91%
- there is no significant difference between PBL and traditional course	3%	9%
Teacher's comment: from students' perspective the PBL approach is considered far more appropriate for engineering education.		

5. CONCLUSION

Traditional approach to engineering education on FESB is strictly teacher-centred, i.e. based on students listening to teachers. All courses focus on developing knowledge by gathering facts from teachers, learning those facts and then answering questions on exams. However, the high drop-out rate on engineering studies could not be neglected. The major reason why student give-up their studies, concluded from a number of analysis, is the low motivation and "boring" studies. Two-year experience with GIS course, presented in this paper, showed how students' motivation can change with different teaching and learning approach. The positive effect of introducing PBL approach to students' motivation, visible through surveys, showed that PBL can significantly influence students' motivation in a positive way. It is also significant result that students, as well as teachers who participated in GIS course, consider the PBL approach as better for gathering knowledge, which is one of the "fears" of teachers who advocate traditional approach. The analysis showed that grades have not changed, thus the grading system is not of a major concern for transition to PBL. It should be noted, however, that grading is a major problem for teachers on PBL courses since there is a lot of teamwork included in projects and it is difficult to clarify and assess each student's impact on project outcome. The most important effect is that students experience the PBL approach as far more appropriate for their future work as professionals and they consider it very important not only for developing necessary technical knowledge but also for developing skills like communication, cooperation, team-work, etc. From this we can conclude that application of PBL approach to engineering courses is essential to increase the quality of studies and is necessary in order to motivate students to finish their studies as well as to educate engineers for future industry needs.

6. REFERENCES

[1] Self-analysis of Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, In Croatian, FESB, University of Split, 2012.

[2] Guedes Soares, C.; Parunov, J.; Blagojević B.; Grubišić R.: Zamarin A.; Žiha K.; Ehlers S.; Klanac A.: Tokić G.: Experience and Sustainability of International Curriculum Development in Naval Architeture. University of Zagreb, FSB, ISBN 978-953-7738-00-6, 2010.

[3] Blagojević, B.; Ban, D.; Ljubenkov, B.; Jadrešić, K.: Integrated active learning in Naval architecture studies. 21st Symposium Sorta, 2-4 October, 2014, Baška, Island of Krk, Croatia.

[4] Blagojević, B.; Kuttenkeuler, J.: On project based learning in traditional engineering studies. 19th Symposium Sorta 2010, October 2010, Lumbarda, Korčula, Croatia, pp. 497-509.

[5] https://statistika.hzz.hr; On-line statistics of employement in Croatia.

[6] Crawley, E.F.: The CDIO Syllabus v2.0 An Updated Statement of Goals for Engineering Education, Proceedings of the 7th International CDIO Conference, Technical University of Denmark, Copenhagen, June 20 – 23, 2011.

[7] de Graaff, E.; Kolmos, A.: Management of Change Implementation of Problem-Based and Project-Based Learning in Engineering, Netherlands: Sense Publishers, 2007.

[8] Kolmos, A.; de Graaff, E.; Du, X.: Diversity of PBL - PBL Learning Principles and Models. In Du, X; Graaff, E.d.; Kolmos, A., eds. Research on PBL Practice in Engineering Education. Rotterdam, Sense Publishers, 2009. pp. 9-21.

[9] Crawley, E.F.; Malmqvist, J.; Östlund, S.; Brodeur, D.R.; Edström, K.: Rethinking Engineering Education, The CDIO Approach, Second edition, Springer International Publishing, 2014.

[10] Malmqvist, J.; Young, P.W.; Hallström, S.; Svensson, T.; Lessons Learned from Design-Test-Build-Based Project Courses, International Design Conference – Design 2004, Dubrovnik, May 2004.

[11] Johnson, P.: Problem-Based, Cooperative Learning in the Engineering Classroom, Journal of Professional Issues in Engineering Education and Practice, 125(1), 8-11, 1999.

[12] http://www.zakon.hr/z/566/Zakon-o-Hrvatskom-kvalifikacijskom-okviru.

[13] Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R.: Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain. New York: David McKay Company, 1956.

[14] ASIIN: "General Criteria for the Accreditation of Degree Programmes; Subject-specific criteria complement, TC04-Informatics and computer science", 2015.

[15] ABET: "Criteria for accrediting engineering programs", ABET 415 N. Charles Street Baltimore, MD 21201, USA.

[16] ENAEE: "Framework standards and guidelines ", EUR-ACE®, 31st Edition, March 2015.