

PROBLEM BASED PROJECT ORIENTED LEARNING AS A NEW PEDAGOGICAL TOOL IN LEARNING PROCESS AT THE DEPARTMENT OF GEODESY AND GEOINFORMATICS

Invitation paper

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Summary: *This article deals with a new approach for building the professional competences in the area of geomatics of future surveying and geodesy professionals at the Department of geodesy and geoinformatics, Faculty of Civil Engineering (DGG FCE). The main attention is paid to the Project Oriented Problem Based Learning (POPBL) pedagogy as a new type of developing the professional skills of geomatics professionals. The article will try to study good cases of the new pedagogy involved into the learning process in some EU universities and the appropriates of the POPBL approach to be included into Faculty of Civil Engineering, Department of geodesy and geoinformatics. PBL is one activity of the new Erasmus+ project that is currently in progress at a regional level in which the DGG FCE was included. The objective of the above mentioned Erasmus+ Project is to implement POPBL into the learning process as a new tool in obtaining good personal and professional skill of the students.*

Kew words: *Problem based learning, Geomatics, Faculty of Civil Engineering, Department of geodesy and geoinformatics, Erasmus+.*

1. Introduction

At the DGG FCE, a new study programs were accredited in 2013 and the accreditation is valid until 2018. It is a classical teacher-oriented program covering three well known European higher education areas (EUHEA). It consists of bachelor, master and doctoral study levels. Bachelor program lasts three years and it is common to all enrolled students. Master program lasts two years and it is divided into three modules – Surveying, Geoinformatics and Land management. PhD level is two years program. All above mentioned study programs have lectures, exercises, seminars, practice, etc. Learning pedagogy at DGG FCE was not changed for a long time. It lacks active involvement of the students and the teacher's role is a classical one. The teachers define the subject objectives and transfer the knowledge to the student who is passive and mainly invited to reproduce the knowledge and apply it in problem solving, if they faced them. New learning methodology change the way of learning by putting the students into subject of the learning process that create their professional competences related to the problems they need to solve, in accordance to real market needs. Teacher is a facilitator of the process, not someone who propose solutions but one who manage the learning process toward the new skills and new learning outcomes. It is expected that the students would be more competitive, more cooperative and well experienced after the graduation and is expected to get the job easier. That is the reason why we are thinking about using POBL approach and this article tries to analyse some aspects of its integration into education process at the Faculty of Civil Engineering.

At present, DGG FCE is participating a joint European project with title "Modernising geodesy education in Western Balkan with focus on competences and learning outcomes (GEOWEB). This project is funded by European Union's Erasmus+ Programme and coordinated by Royal Institute of Technology (KTH) in Sweden, involving 10 universities in Serbia, Albania, Bosnia and Herzegovina, Sweden, Austria and Spain. The project started in October 2015 and will end in October 2018. It is planned that DGG FCE will implement the PBL pedagogy in its educational programmes, using positive PBL experiences of some European countries.

Project-oriented learning is another new learning method which is very suitable for the needs of modern geodetic labour market. Due to technical development and social changes in many countries, the role of many geodesists

and surveyors has changed from a state-employed technocrat to a manager of well-defined, time-limited, budget-specified geodetic projects. In Sweden and many other European countries, most geodesy graduates will work for technical consulting companies, which often work in project form on a competitive market. Therefore, it is important that future geodesy students are equipped with communication skills, project management skills and skills in working in project form and in groups. Through projected-oriented problem-based learning, geodesy students can receive above important skills.

2. Problem Based Learning in general

History of PBL dated back to seventieth of the last century. It is an instructional approach that has been used for more than 30 years. It has acceptance in multiple disciplines. It is learner centred approach that asks learners to actively take part in their research, integrate theory and practice and use the knowledge and their skills in order to find the optimal solution to a defined problem, [6],[9]. Regarding to Boud and Feletti[2], Medical faculty at McMaster University of Canada introduced this process as a central philosophy of structuring their curriculum in 1969. This approach was adopted in other medical schools during the 1980s and 1990s but later across North America and Europe also. It is important for this approach to select ill-structured problems that are interdisciplinary (often) and a tutor with considerable experiences who manages and guides the learning process toward the expected results. It is not easy to describe the characteristics of a successful PBL. Several authors try ,for example, Torp and Sage [14] to describe PBL as an experimental learning focused to the investigation of messy, real-word problems. They identify the role of the tutor, responsibilities of the learners and the main elements of ill-structured problem design as the driving force for students' activities. To transform a teacher as knowledge provider to become tutor and facilitator of the learning process is the main challenge for many who adopt PBL. It is not so complicated to present the problem to the learners but the teacher needs to have highly comprehensive skills in order to support the development of problem solving skills, self-directed learning and team work collaboration skills at the expected level which guarantee the future students capabilities in solving the similar problems. Because of the very importance of the tutor role, tutor-training programs are permanently organized in the institutions that adopted a PBL approach. Duch, Groh, and Allen [9] and Hmelo-Silver [9] gave their contribution describing the PBL. Howard Barrows [1] defines the concept "*as being student-centred, taking place in small groups with the teacher acting as a facilitator, and being organized around problems*". One way to use PBL is to follow well known seven steps consisted of pre-discussion in group works, individual work and post-discussion in group[15]. The steps defined by Wood [15] were showed in Table 1.

Table 1: Seven steps of PBL,[15]

Steps	Phase of study	Activity
1	Pre-discussion	Clarify text and terms
2		Formulate problem statement
3		Problem analysis
4		Inventory of problems and solutions
5		Formulating self-study objectives
6	Individual	Self-study
7	Post-discussion	Conclusion

Problem based learning today is more used in medical area. In engineering PBL is used in some of them, probably because if the big differences between. There are more basic knowledge like mathematics or physics where classical lecturing is more suitable.

3. Problem Based Learning – Aalborg model

PBL was introduced in Aalborg in 1974 immediately after the Aalborg University was inaugurated. At the beginning it was a hard work but now society accepted that PBL was adding a new value and graduates are well received and the labour market and many educational institutions abroad followed and implemented Aalborg PBL model. The central actors in learning methods development in Aalborg University are Centre for University Teaching, Learning and the IT-Innovation Centre and University Centre for Problem Based Learning - UCPBL.

PBL in Denmark dates back to 1970s, when two new universities were established: Roskilde University in 1972 and Aalborg University in 1974. In Denmark this concept of orientation is more or less the same as PBL definition, that means – a learning methods based on the principle of using problems as starting point for learning, [1], [10]. What is a little bit specific in Danish model is that it is a combination of a problem-based and project-organized approach. Within a defined frame the students analyse and define problems. They work in groups and submit a common project report. The project group has a joint examination but the students will get individual marks according to their activities in total, including individual ones.

So many elements are involved in the problem-based and project-oriented learning models. Within the theory alone, it is not possible to understand it exactly. It could be understood if cognitive approach, the social learning and motivation and social psychologies are coupled. In other words, PBL has been developed on the basis of a number of theoretical principles that have found their way to a pragmatic development. Graaf and Kolmos, [12] explained that the central theoretical learning principles in both approaches concern three dimensions: the problem, the content and the team.

In Aalborg PBL model approximately one half of the student’s time is spent on project group work while the other half is spent on traditional lectures (more or less). The same model is followed from the 1st to the last 10th semester (master’s degree). The groups are made of 6-7 students in the 1st year and reduced to 2-3 in the final semester. The main principles can be described as in Figure 1. The program lasts 10 semesters leading to a Master’s degree. The structure of the curriculum is very deterministic and has a very well prescribed output. The project is offered within the framework of a given theme (open or subject related) and has to be related to the overall broad educational objectives. The project and courses (majority of them) are related to the theme of the actual semester. The students are attending the courses and use the knowledge in their project work. At the end of the semester, the student’s group submits the project report which is examined in a joint group examination with individual marks that takes up to six hours. The work on the project and the courses covers approximately 80% of the semester and is equivalent to 24 ECTS (full semester has 30 ECTS), Figure 2. The rest are compulsory courses. They are assessed in a traditional way. It is important to point out that the structure of the curriculum is progressive and flexible. It means that in a specific theme projects can change from year to year having in mind that a theme covers a great variation of problems (from industry, public, administrative, private, new problems are always welcome) and is well prescribed using Bloom’s taxonomy [3] to explain a learning depth.

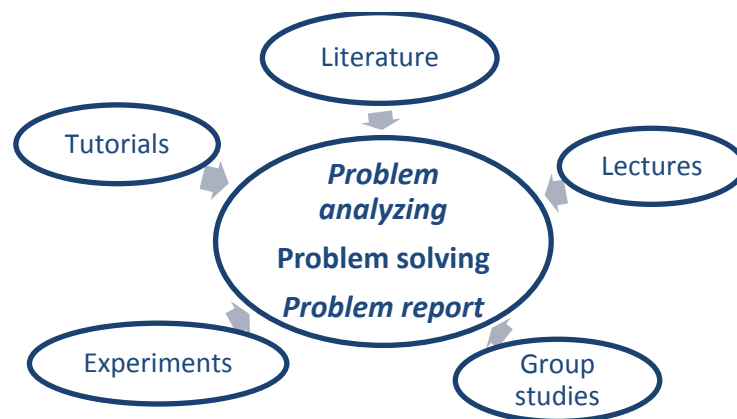


Figure 1: Principles of project-organized problem-solving [11]

One or several supervisors are responsible for each group and their role is to respond to the student’s project process and take them to the examination (in examination, supervisor and an external or an internal examiner are present) in which they are included, also.

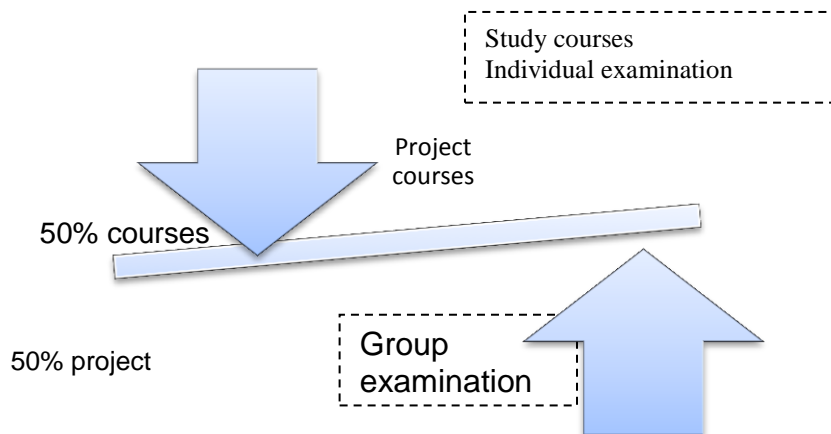


Figure 2: Traditional Aalborg PBL model

4. Problem Based Learning – Portugal

In Escola Superior de Tecnologia de Gestao de Agueda – ESTGA, PBL was established in Geoinformation engineering [4]. It is a three year study program. Photogrammetric education is organized during the second year where in one semester a theme photogrammetric restitution is candidate. After that, the students continue with cartographic production with the data gathered before, during the photogrammetric activities. During the work, the students have various types of getting the knowledge in parallel with the project as the final result of the activities on actual chosen theme. At the beginning of the semester the students have lecturers, but later project work is a prevailing activity. At the end, students have the examination where they publicly defend their projects in front of the committee. The themes were chosen with the help of production companies. That is reason why the students are motivated and expect to get the job easier. Even though the PBL way seems to be a little bit confusing, it is general opinion that this way of learning is more oriented to the labour market expectation.

5. Problem Based Learning – Aalto University model

PBL was introduced at the Institute of Photogrammetry and Remote sensing, Helsinki University of Technology Finland several years ago, using the experiences of Portugal and Denmark. However, this was done in a rather limited scale. The innovation-oriented exercise was thrown within the three credits (equivalent to ETCS point) course of Fundamentals of Photogrammetry [7]. The course started in spring 2009, lasted seven weeks and the second year students of Geomatics attended it. Several companies in the field of photogrammetry were included and large amount of resources were occupied at the Institute of Photogrammetry and Remote Sensing where the learning process was placed. The research staff from the Institute was engaged as tutors within the learning process, too. The average group had four students with 27 students in total. Each group had a tutor and the students were asked to become familiar with production processes in a real company and to be ready to discuss and select the problems to be analysed during the study without obligation to be implemented, but that could probably improve the process. It gave the students freedom to create ideas and to be more futuristic. All ideas were expected to be connective with the real photogrammetric companies' products or activities. One of the prerequisite was that the group work should be creative and fun, not much serious for the young students. In Table 2 time schedule and tasks were showed.

Table 2: Time schedule and group work activities [7]

Week	Activities
1	Starting (group creation and company selection for each group) Contact the company selected
2	1-2 group meetings Collect data of the company (activities, application, clients, products, ...)
3	Visit the company 1 group meeting Select the area to start generating the innovation
4	1 group meeting (focus the area of innovation and work on it) Visit the company (find more information about selected innovation area, during this or next week, the second visit)
5	1 group meeting (work on innovation)
6	1 group meeting (work on innovation, report preparation) Return the report
7	Closing event for the exercise (each group presents innovation and acts as an opponent for the work of the another group, provide questions and comments, etc.; examples of problems: visualization and examination laser scanning point clouds or production of 3D city models, creation of new and more effective data acquisition methods - instead of mobile mapping, the UAV was used for data collection, etc.) Present the innovation to the company as well. (There were 32 questions that the students should answer. The questions were divided into five groups and selected related to organization, workload, companies, group working and motivation).

The PBL philosophy used is oriented toward large project work in which the courses are implemented and where the students are offered with new learning experiences. The students are expected to suggest an innovation. Photogrammetric companies were involved into the learning process giving the chance to the student to be familiar with the working environment. On the other side, the companies will use and implement new ideas in their work.

6. Problem based Project oriented Learning – new environment to make competences at DGG FCE

Modernization of professional practice driven by technology development forces the educational institution to change the learning process. New modern equipment, global technology, internet, remote sensing, socio-economical changes, etc., become the content of study process asking the teachers to develop their own skills in order to help new generation of students to learn and use new capabilities of the instruments. Internet become a new vary powerful toll for getting knowledge from various sources of information and open databases. Communication capabilities are now almost unlimited and give a lot of new ways for experiences to exchange. In such a situation it is reasonable to answer the question –are we on a right road and do we really use all learning possibilities that are at our disposal now? Cooperation with the real companies in the area of geomatics became obligatory task for every educational institution everywhere and in Serbia also.

Since 2013, the new study programs have been accredited at the DGG FCE at bachelor, master and doctoral levels. Table 3 shows a list of courses at the Land Management program, one of the three different divisions of the same master study program at DGG FCE. It is classical teacher-centred and subject oriented program with lecturers, exercises, field work and seminars where the students solve some "non-realistic" problems not directly connected with the real market needs or companies' requests. The context of personal skills development is not specially planned and it is just a result of individual efforts.

Table 3: Existed classical learning model at the DGG

Sem.	List of courses per semester and number of ECTS credits					
4	Master thesis - O 20 ECTS	Professional practice – O 2 ECTS	Research work – O 20 ECTS			
3	Land Consolidation 2 - O 5 ETCS	Property valuation - O 5 ETCS	WEB GIS Remote sensing or Project management <i>Two out of three</i> E, 5 ECTS	Geodesy in urban planning or Infrastructure or Natural resources E, <i>one out of three</i> ,	Geodesy project for urban planning or Project in RE Cadastre - E, <i>one out of two</i> ,	
2	Property investment analysis –O 5 ETCS	Real Estate Cadastre 2 - O 5 ETCS	Land Consolidation 1 - O 5 ETCS	Project methodology – O 5 ETCS	Urban Land Management - O 5 ETCS	IT in Cartography or Negotiation and communication E, 5 ECTS
1	Property market - O 5 ETCS	GIS - O 7 ECTS	Property low - O 7 ECTS	Environmental and space planning law - O 6 ECTS	Geostatistics or Environmental protection E 5 ECTS	

O – Obligatory courses, E – Elective courses

Regarding to the new philosophy of learning, a new type of learning is proposed with the additional aspects on how to find time for the project work and personal skills and abilities development. Table 4 explains the basic concept of a new learning idea as implemented within the Land management study program. Program that is proposed respects real market needs and the knowledge according to the real problems. It is for the first time in the engineering disciplines, especially in geomatics, that's such kind of learning process, is proposed in Serbia. The idea is similar, like that used in Alto or something between Alto and Aalborg cases. This proposal accounts for surveying companies as the market oriented companies to be interested in employing the best students ready to solve problems. Also, it is expected that academic staff is applicative oriented and the students are the most interested party willing to obtain appropriate skills and competences for doing their job successfully satisfying the employer's needs. This proposal is some kind of so-called *blended learning* that assumes a portion of the traditional face-to-face courses to be replaced by web-based online learning. Online courses are supposed to be supported with e-learning material where 50% of the whole content is delivered online or face-to-face. Online

learning could be video-recorded lectures, text chats or some other digitally enabled learning activities with the instructions that teachers provides to guide the students' work.

During the semester each group of 3-5 students with their tutor go to the surveying company screening the activities related to the property problems – border location, ownerships, right to use, land quality, planning rules, etc. The students chose the problem of interest to exercise on and select it as a theme for the group to analyse and to study. Following the procedure roughly explained in Table 2, with the help of the tutor, they actively participate in organization of the lecturers providing knowledge they need to solve the actual problem that they have already selected. During the semester the group visits the company two or three times collecting the information they need to implement the project. After the project is completed and report prepared, the students present their work (project) to the company, tutor and students that worked on other projects. After the discussion, the students' work and knowledge is evaluated and individual students' grades assigned.

Table 4: Proposed PBL model at the DGG FCE

Sem./ Weeks	Curricula content – Problem based and Project oriented Learning		
4/12	Preparatory research work – 10 ECTS Master thesis - 20 ECTS		General outcomes [6] <i>Cooperation skills and project management - P</i> <i>Linguistic skills - P</i> <i>Ability to work in teams and manage teamwork - P</i> <i>Ability to organize complex work and solve problems - P</i> <i>Technical skills - T</i> <i>Problem solving abilities – T/P</i>
	Project work and courses – group work	ECTS	
3/12	Problems focused to market needs – level 3 <i>Working group with 3-5 students, self-study</i> <i>Project work, six weeks</i> <i>Responsible tutor</i>	15	
	<i>Courses of interest to be organized as lectures aimed to develop personal and technical skills on themes chosen from actual market research in cooperation with professional companies.</i>	15	
2/12	Problems focused to market needs – level 2 <i>Working group with 3-5 students, self-study</i> <i>Project work, six weeks</i> <i>Responsible tutor</i>	15	
	<i>Courses of interest to be organized as lectures aimed to develop personal and technical skills on themes chosen from actual market research in cooperation with professional companies.</i>	15	
1/12	Problems focused to market needs – level 1 <i>Working group with 3-5 students, self-study</i> <i>Project work, six weeks</i> <i>Responsible tutor</i>	15	
	<i>Courses of interest to be organized as lectures aimed to develop personal and technical skills on themes chosen from actual market research in cooperation with professional companies.</i>	15	

P – Personal skills, T – Technical skills

PBL is often confused with problem-solving (classical, so far learning style of learning). Traditional teaching method may require students to apply knowledge provided by the teacher to the solution of a problem. They do that in order to show that they have understood the theory or in order to demonstrate the applicability of the theory to practice. It is not PBL, because in a PBL curriculum, the problem comes first and the students discuss the problem and work out what they need to learn. Also, operational plan for having topics that need to be built into the curriculum is discussed with the students. Choice of the semester where actual problem and topics should be addressed and focused on is subject of discussion, too. In Table 5, differences between PBL and problem solving styles of learning are shortly presented. Program planners must decide at which semester various topics need to be addressed. Answers to questions such as: how to integrate some topics into the curriculum, how to define objectives and outcomes are some of the most important tasks for the planners, so they should be well prepared and capable to solve them.

Table 5: Main differences between PBL and problem solving attributes

Attributes	PBL	Classic
Teacher	Advisor or facilitator, must update his knowledge	Teacher transfers the knowledge to the student independently of the real market problem (often)
Student	Influence on the contents of their learning, student centered	No influence to the content of the course
Evaluation	External	Internal
Type of learning	Problem is part of the theme, group work, small groups	Subject of the learning is course content, individual work, large groups in exercises (often)
Relation with practice	Strong connection between research and practice	Usually there is no direct connection
Creativity and phantasy	Yes	No imperative

7. Conclusion

In the article PBL was explained as a tool for making the competences of the students during the learning process at the higher education level. Examples of good cases were given and the idea to introduce PBL into the learning process at the DGG FCE was proposed and analysed. Land management division of the actual MSc program at DGG FCE was used as an example where PBL could be implemented. This is only the first step in order to promote PBL idea at the DGG FCE. We expect the actual Erasmus+ project GEOWEB to help in better description of this process and that during the project life experiences from good PBL examples will be promoted and transferred and implemented into DGG FCE studies. PBL will be only one part of the new web based system that assumes MOODLE Learning Management System to be implemented in a new e-learning methodology that was planned under Erasmus+ GEOWEB project until 2018.

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