GEO BIZ

BUSINESS DRIVEN PROBLEM-BASED LEARNING FOR ACADEMIC EXCELLENCE IN GEOINFORMATICS

2019-2022

HOW TO IMPLEMENT PBL INTO A LEARNING PROCESS

Practical guide

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Co-funded by the Erasmus+ Programme of the European Union

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CONTENT

FOREWORD

The need for new professionals who complete their studies to be able to independently solve tasks and problems in today's academic education system is becoming more and more pronounced. At the same time, higher education institutions struggle with the impossibility of equipping them with modern equipment, especially in the STEM field, which is particularly exposed to rapid technological changes brought about by the digital revolution. The very ability to solve tasks and problems is not innate by itself, but needs to be developed, which is not easy or particularly successful when applying classical forms and methods of teaching. Therefore, the methodology of problem-based learning was developed, which is imposed as an alternative to classical forms of teaching. Problem-based learning can be applied at the level of subjects, modules or the entire study program, but regardless of the scope, in all cases it is necessary to adhere to the teaching methodology and the rules that have been developed.

The Erasmus+ capacity-building project in higher education "Business driven problem-based learning for academic excellence in geoinformatics" - GEOBIZ realized from 2019 - 2022 aimed to improve the practical parts of teaching courses in the field of geoinformatics, the contents of which are particularly exposed to rapid technological changes. The solution was found in the strengthening of cooperation between the business and academic sectors and the inclusion of companies in the teaching process. Both, using of practical cases from the practice of companies prepared for the implementation of the practical part of the lesson, and through the introduction of problem-based learning in the approach to that practical as well as theoretical teaching. University of Belgrade, Faculty of Civil Engineering under the leadership of prof. Branko Božić was responsible for the introduction of problem-based teaching in new and modernized courses created by the GEOBIZ project. In addition to 25 new or modernized courses and established cooperation between partner universities and business companies, the result of the project is this practical guide on the implementation of problem-based learning in the teaching process.

In a simple way, supported by examples, prof. Božić presents in this guide the methodology of problem-based learning and how it is implemented in the teaching process. This concise summary guide is focused primarily on the field of geoinformatics, but the presented methodology and instructions can be implemented in any STEM field, and beyond. Therefore, this guide represents a concrete and valuable contribution to the learning process in higher education, and as one of the results of the project, we are pleased to present it to the public with thanks to Professor Božić for his commitment and effort.

Prof. dr. sc. Željko Bačić

GEOBIZ Project coordinator

1 ERASMUS+ CBHE GEOBIZ PROJECT

GEOBIZ project is covering all partner countries from Region 1 – Western Balkans, and one country from Region 2 – Eastern Partnership countries (Moldova). There are Regional and Cross-Cutting Priorities common for regions from which targeted countries and one relevant priority for Eastern Partnership countries. Those priorities have been addressed in following manner: Modernisation of curriculum, Internationalisation of higher education institutions, University enterprise cooperation and Knowledge triangle, innovation (priority for Eastern Partnership countries). Additional to priorities in Regional context and ways how they will be addresses, new (national) priority was New technologies in higher education.

All targeted Partner Countries involved in GEOBIZ project (Albania, Bosnia and Herzegovina, Kosovo, Moldova and Montenegro) have chosen ICT education as one of the, or better to say the one, priority area of higher education. Geoinformatics is applied part of ICT education, regardless to the fact that it is lectured in different study directions, like Partners involved in our project which deliver study programs in geodesy, civil engineering, ICT and geography field.

Internationalisation is recognized as necessity and chance for development of higher education in Partner Countries especially in the areas which are contributing to/or are influenced directly by global trends (ICT, geoinformatics). GEOBIZ project aimed to provide passive and active instruments of internationalisation of higher education, but also business sector, in Partner Countries. Passive in mean of transfer of information, knowledge, skills, methodologies and practices, while active in supporting partners becoming members/participants of relevant EU and international initiatives. Partners will be encouraged to join such activities and transfer them in own ecosystem. Dependent on partner this goes for joint studies, establishment of start-up incubators, conducting science and education promotion activities (like hackathons), etc.

The modernisation of higher education is addressed in national and HEI strategies on numerous places and is reflected through national priorities which Partner Countries have defined for themselves in Erasmus+ programme. Common predominant priorities for targeted Partner Countries like University enterprise cooperation, Knowledge triangle, innovation, new technologies in higher education and Lifelong learning, continuous education are all focusing and contributing to modernisation of higher education. With the respect to geoinformatics, keeping in mind that globally geoinformatics has just recently been profiled as recognizable study, there are seldom strategies which are explicitly addressing it. In this context GEOBIZ project, together with other major and strategic Erasmus+ projects like EO4GEO, are creating environment to develop geo-spatial/geoinformatics strategies in higher education and societies in general.

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2 INTRODUCTION

The development of learning methodology is a complex process that requires a serious and comprehensive approach that must be carefully planned and implemented in accordance with the needs of educational development and meeting the real needs of a community (URL 1). The development of a learning model can be grounded through a deductive or inductive approach (Tan, 1994). Deductive models are based on the analysis of the needs of society as well as the needs of the development of a profession. Inductive models start from the analysis of the existing study program and consideration of its global aspects. It must be based on the analysis of the needs of the society and the levels of the discipline development. The development of the study program can have different levels. When it comes to the introduction of the PBL methodology, several different approaches are possible. The most complex is certainly the approach that implements PBL at the level of the entire study program (mega level). If PBL is introduced by groups of related areas or subjects it refers to macro level, because only a part of the study program is included. If PBL is implemented in one or several subjects separately, then it is micro level. Again, at the micro level PBL can be incorporated at various course levels, at a course as a whole or at the level of one or more topics or even in practical part of the course[1].

This material provides basic guidelines and contents necessary for the implementation of PBL at the level of one course. It includes the realization of teaching content through solving problems (cases) in mutual cooperation and communication of students following the PBL methodology which should be harmonized with the expected outcomes of the educational process.

PBL implementation starts with the statement of the course objectives. After the decision where to incorporate PBL into the course, the teacher needs to specify PBL objectives (problem solving, active learning, critical thinking, peer learning, teamwork, presentation skills, etc.) and think how to include them into the existing course syllabus.

In the next step, PBL specific and course content learning objectives regarding the nature of the PBL cycle should be combined. Timeframe for the whole cycle and time-table for each stage, PBL tutorial hours including time for self-learning and type, scope and number of problems are defined. The course structure should follow PBL learning cycle starting with problem clarification and analysis, brainstorming previous knowledge, generation of learning issues, research and field work, reporting and peer learning, presentation of the results and reflection and evaluation.

A key step in PBL implementation is the design of the problem. The responsible teacher should think how to design the problem. In order to design problem properly, the teacher has more options. He can do that alone, with the help of other professional organizations that work at the market or with students remembering their previous knowledge and experience obtained during their practice and so on. According to (Hallinger and Bridges, 2007) some problems are highly structured, while others are complex, messy, and ill-defined. All problems may take one of the following forms:

- **The swamp**, consisting of a complex problem that contains numerous sub-problems
- **The dilemma**, in which the tutor knows what is wrong but must choose among alternatives involving a sacrifice or trade-off of important personal and/or organizational values or objectives
- **The routine problem**, one that most tutors encounter regularly in their work.

[1] GEOBIZ requested

- **The implementation problem**, in which the tutor must figure out how to ensure the successful implementation of a new policy or program.

Teachers are responsible to develop or prepare learning material for students, guides for PBL learning process and to describe the roles of participants in learning group, including learning environment and criteria for valuation (assessment).

The assessment drives learning and it is based on PBL oriented course outcomes. Except assessing the acquisition of content knowledge (remembering facts or pure reproducing the knowledge), teamwork, problem-solving, critical thinking, communication skills, need to be evaluated, also. A teacher has a various types of assessment methods to use and what he will find suitable depends on the nature of the course, teacher experience or assessment school's rules.

At the end of the course or at the end of each problem, if the course contains more than one problem, it is necessary to evaluate effectiveness of the learning process. The teacher and students should analyze the feedback obtained from students and others participating in learning process (representatives from private or public companies) in order to improve the various aspects of the learning process in the future.

3 PBL WORK METHODOLOGY (PBL LEARNING CYCLE)

Problem-Based Learning (PBL) is a teaching method in which complex real-world problems are used as the vehicle to promote student learning of concepts and principles as opposed to direct presentation of facts and concepts. In addition to course content, PBL can promote the development of critical thinking skills, problem-solving abilities, and communication skills. It can also provide opportunities for working in groups, finding and evaluating research materials, and life-long learning (Duch et al, 2001).

At the beginning of learning, the teacher explains the basic characteristics of the PBL approach to learning. Teamwork, development of critical thinking, importance of mutual communication and distribution of obligations, exchange of knowledge and ideas, selection of the optimal solution and presentation of the same are pointed out. Students are divided into groups of 3 (5) to 5 (8) students. The work takes place according to a defined scenario or project or professional problem, within the following phases (Barrows and Tamblyn, 1980; Camp at all. 2014):

1) Clarification of vague expressions and terms (each team member must be clear of any expression or term within a given problem).
2) Defining requirements according to a given problem (a problem or scenario can also be defined through several questions asked or given problems with clear requirements to each team member).
3) Analysis of previously acquired knowledge in the context of a given professional problem (solutions are collected with the active participation of all students, students are reminded of previously acquired knowledge in the context of a given problem, present solutions and formulate hypotheses in support of solving the problem, without critical analysis).

4) Proposing possible solutions to the problem (students discuss the collected solutions from the previous phase, critically consider them and select them according to the quality and possibilities of solving).

5) Formulation of necessary knowledge and skills to be mastered in order to find a solution (in accordance with the analysis and in the context of the problem, certain topics are formulated - learning content - which through the learning process allow students to acquire knowledge and skills needed to solve problems and learning outcomes for each selected topic, distributing the learning content as evenly as possible across each team member).

6) Individual work on finding literature, mastering the necessary knowledge and skills according to the distribution of obligations and mutual exchange of information (according to defined topics and outcomes, students individually collect literature and acquire the necessary knowledge and skills, and then prepare to present and present acquired knowledge to other team members, taking into account the context of the problem; students exchange knowledge, ask each other questions, until everything is completely clear to everyone).

7) Preparation of a technical report, presentation of results and evaluation of activities and processes (students in accordance with the defined content synthesize their previous work and prepare a technical report, prepare a presentation and present the results of their work, where each student:
    a) evaluates his / her work and contribution on certain issues,
    b) evaluates the work and contribution of other team members and
    c) evaluates the efficiency of the PBL learning process and tutors).

The first five phases belong to the preliminary or previous part of the active process, the sixth phase is independent learning and the seventh is reporting and evaluation. Within the learning process, the teacher is in the role of a guide, tutor who encourages and directs the work of the group, motivates them and creates an adequate atmosphere that implies active engagement of each member in all phases of the work. The teacher should not provide solutions or serve the necessary learning content. Instead, he should guide and assist in the selection of literature, content creation, learning outcomes and the final report. Individual members of the group, in addition to general, also have specific roles. At each group work session, a team leader and a scorer are elected. Some other roles can be devised, but the first two are basic.

The team leader leads the discussion in the problem-solving process and presents the solution. He actively encourages other members to actively participate in proposing, analysing and solving a given problem. The team leader must know and adhere to the procedure (phase) of the PBL process, prepare and lead the meetings well, stimulate the participants' discussion, summarize individual discussions and draw concise conclusions, ask questions and seek answers to them. The role of the scorer (the scribe) is to actively monitor the discussion and register the key elements, ask a question if he did not clearly understand the presented proposal, and clearly record all relevant discussions and proposals.

In the first session, the team leader is expected to invite the members of the group to get acquainted with the problem and to check the same, determine whether there are vague terms and terms, summarize the conclusions and announce the next meeting. The scorer registers the conclusions and the nuance of the terminology.

In the second session, the team leader determines whether the group members understand the defined requirements, indicates the contribution of each individual in understanding the problem, draws conclusions and announces the next meeting. The scorer registers the key requirements of the set problem.

In the third session, the group leader requests and stimulates the active participation of each individual and his contribution to the perception of the set requirements on the basis of previously acquired knowledge and skills without critical analysis of proposals and discussions. The scorer summarizes the discussions briefly and concisely, separating the key ones from the secondary requirements.

In the fourth session, the group leader takes care to analyze all the ideas presented in the previous step. It requires the active participation of all members in the analysis of previous knowledge and new requirements in terms of necessary knowledge and skills that were not recognized in the previous learning process. The scorer registers the new contents to be studied and the summary of individual discussions.

In the fifth session, the group leader insists on setting learning goals and asks that individual members actively participate in it, taking into account that all goals related to previously defined new content follow certain measurable learning outcomes and that all team members agree with it. The scorer registers the set goals and outcomes as well as the individual obligations of individual members.

The sixth session is individual work on the realization of the set learning goals, exchange of knowledge among team members.

According to Gino (Gino at all. 2014) the team leader should:

- ensure a correct application of the seven-step approach,
- structure the tutorial meeting,
- stimulate all group members to contribute to the discussion,
- summarize and paraphrase contributions of group members,
- ask questions and promote the depth of the discussion.

On the other hand, the scorer (the scribe) should (Gino at all. 2014):

- listen actively, selecting important points and noting them down, if necessary,
- ask questions to clarify or check if what noted down is correct,
- express information succinctly, using keywords and abbreviations,
- structure information on the board, if possible, by visualizing information in a drawing or table and
- write quickly and clearly.

In the seventh session (step), the team leader defines the process of presenting the results, makes a list of used literature, states individual learning goals and requires other members to report on them, summarizes individual contributions of members, asks questions, stimulates participation of each individual, summarizes results and evaluates success. Finally, no less important is the evaluation of the work and contribution of the individual as well as the efficiency of the entire learning process.

The sessions can be combined, but each session is preceded by a work agenda that must be forwarded to the group members in advance. It is adopted at the scheduled session, followed by a discussion. The scorer keeps notes from the meeting and in the shortest possible way compiles the minutes with the basic views and presented or adopted proposals of each individual member of the team.

It is especially important to emphasize the role of the tutor, the teacher who is responsible for managing the learning process according to the given problem. Gino at all. in (2014) lists two groups of skills that a tutor should possess. The first set of essays refers to the PBL process itself, and the second to the content of the topics of the area to which the subject (course) belongs.

In procedural terms, the tutor should:

- Ensure efficient and effective application of the phase structure of the PBL algorithm,
- Assist in the work of the team leader and the scorer,
- Stimulate the event engagement of all team members,
- Stimulate discussion through asking questions and
- Point out observed omissions and influence them to be corrected.

In terms of content, the tutor should:

- Stimulate professional discussion,
- Direct questions by directing the discussion and pointing out omissions,
- Provide certain information in terms of encouraging members to reach the desired answers through discussion and literature,
- Guide team members in connecting different content,
- Intervenes at the right time, if there are disturbances or delays in the work of the team,
- Ensures that the discussion is not unnecessarily wide and helps to identify key ones of less importance.

In PBL students collaborate in small groups. They are expected to examine gaps in their knowledge and skills (Savin-Baden and Howell, 2004). In other words, they should define what information they need to acquire in order to solve the problem.

After each team meeting, it is desirable to analyze the previous work of the team, in groups and individually. It is very important from the aspect of raising attention and motivation in work to permanently analyze the feedback that is obtained by evaluating the efficiency of work and the individual overall contribution of team members. This creates the possibility of a critical review of the activities of individuals during the PBL process in order to further improve the attitude towards obligations in the further course of work.

Effective feedback should (Gino at all. 2014):

- Be well-intentioned and constructive, not judgmental,
- Concrete and clear,
- Useful to the one to whom it is addressed,
- Not only indicates a negative attitude but also to point out positive examples of behaviour and work, and
- Expressed from the perspective of the one who expresses his personal position.

4 EXAMPLE OF THE COURSE REALIZED WITH PBL APPROACH

Study program: Master program - Geodesy
Year/Semester: First/First
Course: Adjustment calculus – advanced
Lecturer: BB
ECTS: 4

Course objectives - to master the procedures for solving the problem of estimating unknown parameters in the models of geodetic measurements through designing geodetic control networks for the purposes of staking out, building infrastructure, geometry control and exploitation monitoring of infrastructure facilities.

Learning outcomes - After the realization of the learning process, students should independently and through teamwork under the supervision of teachers, solve the problems of designing geodetic network using all available literature and information technology and adjust realized geodetic measurements. Students should be able, independently and through the teamwork, to critically analyze and select an optimal geodetic datum, network design, devise the plan of geodetic measurements and test the hypotheses according to the given criteria of accuracy and reliability in accordance with the real professional needs.

Problem/Scenario - In a part of the territory measuring 2 km x 3 km, it is necessary to design a free geodetic network for the needs of construction and monitoring the stability of the engineering facility. Measures of accuracy and reliability of estimates in the geodetic network should be harmonized with the allowed tolerances of the object's behaviour. In accordance to the observation plan the measurements should be simulated, network adjusted and all required results reported.

Learning method: PBL learning cycle (General PBL concept, activities, objectives and outcomes - Table 1 and 2)

Table 1: PBL learning cycle – general PBL concept

Session	Activity	Time frame
1	Introductory lectures / Geodetic control networks, datum definition, quality and reliability measures, statistical hypotheses, error modelling and stochastic models	Date: Time: 8 – 10 h
2	Forming a group, introduction to PBL, explaining the meaning of certain expressions and terms within a given scenario (asking questions, clarifying concepts, all team members must understand the requirements)	Date: Time: 2 h
3	Defining the problem (highlight relevant requirements crucial for solving the problem) Analysis of previously acquired knowledge in the context of the problem (presenting ideas, connecting with previously acquired knowledge, what is known and what is new)	Date: Time: 2 h
4	Structuring new content needed to solve problems and set hypotheses Defining goals and outcomes of the learning process	Date: Time: 2 h

5	Realization of the set goals and outcomes, learning, gathering information, individual learning or in pairs (reading literature, using different sources, realization of set outcomes)	Date: Time: 4 weeks (4x2h)
6	Discussion and synthesis of collected information and knowledge, development of the final form, form of presentation	Date: Time: 2 x 2h
7	Reporting/ Discussion/ Evaluation	Date: Time: 3 h

Table 2. The course content with the goals / objectives and outcomes

Activities	Objectives	Outcomes
Defining the design and geodetic network datum	Adapt the shape of the control geodetic network to the given object in terms of geometry. Define the geodetic datum with a minimum trace.	Defined network geometry. Defined geodetic datum.
Making the observation plan	Select the measured quantities, the number of measured quantities and the accuracy of measurements.	Observation plan made Measurement accuracy defined.
Preliminary accuracy analysis (validation of the selected observation plan)	Perform a calculation of accuracy and reliability and compare the obtained values with the given tolerance defined by the terms of reference.	Reliability and accuracy calculation performed. Quality and reliability indicators are within the expected limits.
Defining technical conditions for the realization of measurements	Calculate the conditions for the implementation of field measurements and control.	Defined measurement conditions and accuracy conditions. Calculated measurement control conditions.
Realization of measurements (simulation)	Simulate the measurements in accordance with the plan and accuracy requirements.	Measurement simulation performed.

Processing and analysis of measurement results	Adjust measurements by the method of least squares. Perform an accuracy assessment, test the adequacy of the model and test the measurements for the presence of gross errors. Set up an appropriate hypothesis regarding the geometry of the object and test it for compliance with the assumed value.	Measurements adjusted Model adequacy test satisfied. Measurements do not contain gross errors Hypothesis of compliance with the assumed value fulfilled. Network quality meets the requirements of the terms of reference.
The report	Describe the requirements of the terms of reference. List the existing regulations regarding the construction of the control network. Describe the project solution with previous analysis. Describe the measurement simulation procedure. Analyze the achieved results in accordance with the requirements of the project task.	Project implementation report completed. Presentation completed.

Prerequisite: The prerequisite for attending the course is passing **course Adjustment calculus:** Božić, 2013 (Koch, 1999; Caspary, 2000; Krumm, 2020).

5 Evaluation of the PBL model, individual engagement and engagement of other team members

There are several aspects in the learning process based on which the success of students in the PBL process can be evaluated. Although the final product is an important fact, evaluation should not be reduced to just that fact, since it puts unjustified and too much pressure on the student, creating the impression that the meaning of his learning is to get a grade. Precisely, the purpose of applying PBL is for the student to learn much more than the content of a course. Through PBL, students practice mutual communication through teamwork, develop problem-solving skills and ways of presenting results and ideas, which means that students, in addition to evaluating what they have learned, also acquire knowledge, which is important for the lifelong learning process. Evaluation can have four dimensions: self, peer, teacher and audience. Rubric score sheets, oral and written feedback are possible way for grading. Rubric score can be quick and efficient way of providing feedback to a big class and this type of grading is presented here. Self-evaluation belongs to summative evaluation that consider higher-level thinking and awareness of the material, process and final product. Self-evaluation makes students think about successes, mistakes and goals for the next time (Hernandez, 2016). Peer evaluations are specific for collaborative projects and they facilitate a better collaborative process because the students' experiences are considered by the teacher. The information of the peer assessment is used to modify the workflow for the next project.

Within the evaluation of the results of the PBL learning process, students declare themselves on three grounds:

1) evaluation of personal engagement,
2) evaluation of engagement of other team members and
3) evaluation of learning methodology, quality of literature and the role of teachers.

Evaluation criteria are defined according to the basic PBL mission:

1) contribution to the creation of learning content in the context of problem requirements,
2) level of individual activity in the learning process,
3) level of responsibility and division of responsibilities in acquiring necessary knowledge and skills within the team in problem solving,
4) level of independence and ability to collect relevant information,
5) level of ability to exchange information in the team,
6) level of ability and knowledge in the realization and technical description of the realization of the problem and
7) level of ability to present work results.

The aim of the evaluation is to objectively assess the contribution of each individual and the effects of the new learning model on achieving the basic mission of the PBL model, namely:

1) creating learning content according to a real problem,
2) active attitude of the individual in the learning process, taking responsibility and division of responsibilities within the team to acquire the necessary abilities and skills in the process of solving a real problem in the profession,
3) the ability to independently collect relevant information and exchange and integrate knowledge through the process of teamwork, and 4) adequate presentation of work results.

The evaluation results will serve to objectively assess the individual contribution and further develop the PBL model. Tables 3, 4 and 5 contain questions and statements to which independent and objective answers of the participants are expected. The survey will be conducted in one of the next learning cycles.

Table 3: Self-evaluation (contribution to the work of the PBL team) and teacher evaluation

Questions/marks	5	4	3	2
Creativity in ideas, understanding the necessary knowledge and creating learning outcomes	Creative in ideas, actively participates in identifying the necessary knowledge and creating learning outcomes. Has ideas and no reminders of obligations	Contributed to creativity and ideas, actively participates in identifying the necessary knowledge and creating learning outcomes. Without a reminder of obligations	Actively participates in identifying the necessary knowledge and creating learning outcomes. With occasional reminders of obligations	Participates in identifying the necessary knowledge and creating learning outcomes. With constant reminders of obligations
Contribution to the acquisition of new knowledge and skills / achievement of learning outcomes	Consistently and actively contributed to the acquisition of knowledge, abilities and skills, without recalling obligations	Contributed to the acquisition of knowledge, abilities and skills, without reminding of obligations	Contributed to the acquisition of knowledge, with occasional reminders of obligations	Contributed to the acquisition of knowledge, after reminding of obligations
Contribution to the overall results of teamwork / responsibility according to obligations	Consistently active in work and fulfilment of obligations. Very interested in accepting and fulfilling individual obligations within the group	Works to meet group obligations without encouragement; accepts individual obligations within the group	He works on fulfilling the obligations of the group, with occasional reminders	He works on fulfilling the obligations of the group, with constant encouragement

Communication and exchange of knowledge and skills among team members	Consistently active in communicating with others. Significantly contributes to teamwork, ready to change habits. Acts actively and without recall	Active in communication with others. Contributes to teamwork. Accepts a change of habit. Performs the undertaken obligations and rarely needs to be reminded of them	Communicates with everyone; Modest contribution to teamwork. Accepts a change of habit. It is often necessary to remind him of the fulfilment of obligations	Communicates with everyone; Small contribution to teamwork; Rarely accepts a change of habit; It is often necessary to remind him of the performance of duties; He always or very often relies on others in his work
Leadership skills	Has a significant impact on other team members	Respected by other team members and has an average impact	Respected by other team members but with little impact on results	Respected by other team members but with insignificant impact on results
Quality of presentation of results	Presents his knowledge extremely clearly and completely	Clearly presents the knowledge he possesses	It partially clearly presents the knowledge it possesses	He does not present his knowledge clearly enough
Comment:				
Overall rating:				

Table 4: Evaluating the contributions of other PBL team members

Questions/marks	5	4	3	2
Total contribution in communication	Demonstrated high collegiality towards other members; respects the knowledge, opinions and activities of other team members	Collegial towards others and encourages their activity	Collegial towards others	Occasionally collegial to others
Contribution to building and improving team knowledge and skills / achieving learning outcomes	Consistently and actively contributed to the acquisition of knowledge, abilities and skills, without recalling obligations	Contributed to the acquisition of knowledge, abilities and skills, without reminding of obligations	Contributed to the acquisition of knowledge, with occasional reminders of obligations	Contributed to the acquisition of knowledge, after reminding of obligations
Participation in the exchange of knowledge and skills among team members	Helps others identify needs to change something and encourages others to change; acts actively and without recall	Actively participates in the necessary changes; performs the assumed obligations and it is rarely necessary to remind him of the obligations	Participates in the necessary changes; it is often necessary to remind him of the fulfilment of obligations	Participates in the necessary changes only after reminders and encouragement; he always or very often relies on others in his work
Leadership skills	Has a significant impact on other team members	Respected by other team members and exerts sufficient influence	Respected by other team members but with little impact on final result	Respected by other team members but with insignificant impact on final results
Quality of presentation of results	Presents the knowledge he possesses extremely clearly and in full	Clearly presents the knowledge he possesses	Partially clearly presents the knowledge it possesses	He does not present the knowledge he possesses clearly enough
Comment:				
Overall rating:				

Table 5: Evaluation of the PBL model

Questions/marks	5	4	3	2
PBL scenario (task) quality	The PBL task enables fully active participation of students in the independent creation of the necessary learning content (knowledge and skills)	The PBL task partially provides students with the opportunity to independently create the necessary content	The PBL assignment gives students little opportunity to independently create the necessary content; the content and structure of knowledge are significantly predefined	The PBL task does not allow students to actively participate in creating the necessary knowledge; the content and structure of knowledge are completely predefined
Representation and quality of literature	The scope, quality and approach to the literature are fully adequate	Scope, quality and approach to literature correct; less effort in accessing information	The scope, quality and access to literature needs to be improved; significant effort in accessing information	Scope, quality and access to literature inadequate
The role of the teacher	Significantly encouraged members' activities to communicate with each other and independence in creating content and solving problems	Encouraged members' activities to communicate with each other and independence in creating content and solving problems with less mediation	Encouraged the activities of members to communicate with each other and independence in creating content and solving problems with greater mediation	Encouraged the activities of members to communicate with each other and independence in creating content and solving problems with significant mediation
The quality of the PBL learning model compared to the classical model	Has significant advantages over the classical form of learning	Has certain advantages over the classical form of learning	There are no advantages over the classical form of learning	Has significant shortcomings compared to the classical form of learning
PBL contributes to the development of teamwork skills	Has significant advantages over the classical form of learning	Has certain advantages over the classical form of learning	There are no advantages over the classical form of learning	Has significant shortcomings compared to the classical form of learning
PBL contributes to the skill of presenting results	Has significant advantages over the classical form of learning	Has certain advantages over the classical form of learning	There are no advantages over the classical form of learning	Has significant shortcomings compared to the classical form of learning

PBL contribution to work motivation	Has significant advantages over the classical form of learning	Has certain advantages over the classical form of learning	There are no advantages over the classical form of learning	Has significant shortcomings compared to the classical form of learning
PBL contribution to preparation for professional work	Has significant advantages over the classical form of learning	Has certain advantages over the classical form of learning	There are no advantages over the classical form of learning	Has significant shortcomings compared to the classical form of learning
Comment: 1: Scenario: 2. Literature: 3: The teacher's role: 4: PBL model (state the advantages or disadvantages):				
Overall rating:				

6 SCORING METHODOLOGY

Each student evaluates his contribution to problem solving and its presentation (Table 3). The teacher also evaluates the individual contribution of each student as well as his / her acquired knowledge and skills (Table 3).

Each student in the group evaluates the contribution and level of knowledge of other students in the group (Table 4).

In addition to assessing their own contribution and knowledge, as well as the knowledge of other group members, each student evaluates the quality of the PBL process, the role of the teacher and the quality of available literature (Table 5).

Finally, the teacher weighs the collected individual evaluation results and performs the final assessment. The final grade is analyzed with the students and should contribute to the improvement of the next PBL course.

Table 6: Course syllabus – model proposed[2]

Course title:	**Adjustment calculus - advanced**		
Study program:	Geodesy		
Study level:	MSc, Academic		
Module:	All		
Lecturer:	BB		
Course status:	Obligatory		
ECTS:	4		
Conditional course:	No		
Number of hours of active teaching (per week)			
Lecturers: 1	Exercise:	Additional forms of teaching:	Seminar research work: 3
Course objective:			
To master the procedures for solving the problem of estimating unknown parameters in the models of geodetic measurements through designing geodetic control networks for the purposes of staking out, building infrastructure, geometry control and exploitation monitoring of infrastructure facilities.			
Learning outcomes:			
After the realization of the learning process, students should be able to independently and through the teamwork under the supervision of tutor, solve the problems of designing geodetic networks using all available literature and information technology and adjust realized geodetic measurements. Students should independently and through teamwork be able to critically analyze and select an optimal geodetic datum, design the geodetic network, create the plan of geodetic			

[2] This course syllabus model could be used as a template to design new course with PBL learning methodology. It can be arranged independently of the amount of PBL included. It does not matter how the form of the syllabus should look like, but the essential key PBL elements needs to be included. It means that the real-life problem (case, query, projects, …) is starting point for designing the course learning content. The students work in collaboration, between (group work). Self-directive learning and self-reflective evaluation with the teacher as a tutor need to be included, also.

measurements and test the hypotheses according to the given criteria of accuracy and reliability in accordance with real professional needs.

Course content/Problem

Geodetic control networks, datum definition, quality and reliability measures, statistical hypotheses, error modelling and stochastic models are the content of the introductory lessons. Selected problem (scenario, case) should specify the task which should have an impact on the students to define the content of work in accordance with real-life engineering request (geodetic network) as a part of scenario. Based on real-life problem request, free control geodetic network should be designed for the needs of construction or monitoring the stability of the engineering facility. Measures of accuracy and reliability of estimates in the geodetic network should be harmonized with the allowed tolerances of the object's behaviour. Through the problem solving the students learn how to solve geodetic datum problem and its impact on estimates, hypothesis testing, outliers' detection and the concept of reliability.

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Teaching methods:

Course is realized through classroom lectures prepared in the form of PowerPoint presentations and group students work. In the initial classes, students are faced with the theory of the free control network adjustment and its impact on parameters estimatation. Students do their practical work within a team, according to the PBL model. Students solve a real geodetic problem, within a given period of time which includes the design and analysis of the proposed geodetic network. After the end of the work, a workshop is organized where students, in the presence of teachers and others by invitation, discuss, present their project solutions and evaluate their work, the work of other team members and the entire learning process.

Student workload structure and grade structure

	Lecturers	Pre-exam obligations			Final exam		Total
		Elaborate (practicum)	Project work	Colloquium	Written (Calculation part)	Oral (Theoretical part) / presentation	
hours	30		80			10	120
points	10		70			20	100

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About Author

Branko Božić, PhD was born on 1959. He finished elementary school in 1974 and graduated grammar school in 1978. The Faculty of Civil Engineering - Department for Geodesy finished in 1986, obtained magister's degree at the same Faculty in 1993 on the topic - Variance component analysis in two-dimensional geodetic networks, and received his doctorate from the same University in 2000, the title - Analysis methods of measuring the length with the GPS measuring devices. He worked in the Military Geographical Institute from 1982 to 2002 and in Military Academy - Department of Geodesy (1994/95). From 2002 he was employed at the Faculty of Civil Engineering. He became assistant professor in 2001, associate professor in 2008 and full professor in 2013. From 2006 to 2008 he was director of the Institute of Geodesy and in 2011/12 Head of the Department of Geodesy and Geoinformatics. From 2012 to 2014 he was Vice Faculty dean, in 2014/2015 Acting Dean and Faculty Dean from 2015 to 2018. Published papers, scientific activity and areas of interest are focused on the problems of geodetic surveying, data processing and analysis of geodetic measurements and the application of modern technology in the geodetic surveying. He is author or co-author of four books and three scripts. He made four reviews textbooks, mentor to five PhD theses and a member of the Commission in three.

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