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Edukacja - Technika - Informatyka 3/1, 87-92

2012

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Every year higher educational institutions of Ukraine face the challenge of determining how to efficiently present syllabi, which is constantly increasing in volume, so that students obtain knowledge of the discipline and also become self-directed learners able to develop problem-solving skills which they will apply in further courses and in their careers. Thus problem-based learning (PBL) is considered to be the very integrated environment where learning package data support should be widely applied to act as both a problem-oriented instructional method and technique for learners' progress rating assessment [Козлакова 1996].

This kind of integration requires joining of mutually complementary instructional subsystems on theoretical knowledge and procedures for acquiring practical skills through performing laboratory tasks and practical assignments. PBL is characterized by a student-centered approach, teachers as facilitators rather that disseminators, and open-ended problems that serve as the initial stimulus and framework for learning. Teacher also hopes to arouse students' interest in the discipline, emphasize learning as opposed to recall, promote group work, and help students become self-directed learners. Learning is „student-centered" because the students are given the freedom to study those topics that interest them the most and to determine how they want to study them. Students should identify their learning needs, help plan classes, lead class discussions, and assess their own work and their classmates' work [Gallagher 1997]. Generally, PBL facilitates the teaching-learning process performing its *informative*, *advisory*, *educational-exploratory*, *supervisory* and *attestation* functions.

PBL is introduced into the educational process to promote the use of up-to-date instructional methods based on the innovative information technologies for knowledge presentation. These technologies provide facilities for self-learning along with complex examination of proficiency level of future engineers within their job description in the course of solving real-life research, engineering and technological tasks [Кобзар 2002]. This objective is believed to be achieved through solving the basic tasks listed below:

– evaluate learners' theoretical knowledge acquired during their engineering training;
– evaluate learners' professional skills, their ability to systematically apply the knowledge and skills obtained in the course of mastering engineering disciplines and also in making overall analysis of complex computing tasks;
– evaluate learners' creative abilities to set objectives and tasks for the required research, plan the experiments to be held in the process of solving complex computing tasks needed for working out certain professional problems;
– evaluate learners' logical-analytical thinking they display in generalizing the obtained results and giving arguments for PBL refinement (methods, content of tests and complex tasks etc.). A number of various tests are devised to regularly assess students' progress in acquiring knowledge and skills as well as their decisions-making abilities at various stages of performing laboratory works and computing tasks.

Student assessment seeks to provide a diagnostic tool to ensure students are progressing adequately towards achieving the desired learning goals. Assessment should not be solely a grade-assignment or ranking tool. Too often the learning process degenerates for students into striving to do well on the tests (assessments) so they will have a good grade, rather than focusing on the learning goals of the course. The National Research Council contends that there are three guiding principles to assessment [Mathematical Sciences Education Board 1993]:
– content: assessment reflects what is most important for students to learn;
– learning: assessment enhances learning and supports instructional practice;
– equity: assessment supports every student's opportunity to learn.

Control tests were devised to evaluate the three levels of students' knowledgeability. Thus *general* level tests embrace all the theory within syllabus. At *advanced* level, the skills in specific subtopics related to the general subject area of laboratory classes and computation tasks are assessed. Finally, *detailed* level tests are devised upon subsections of the course which require profound knowledge for carrying out every stage of projects, various computations and scientific research. Speaking of learners' creative abilities and logical-analytical thinking, these are evaluated on the basis of approximate circulation of the students' decisions which provide the most optimal circuit as required by PBL.

These results enable teacher to carry out the overall estimation of students' theoretical and professional engineering skills (along with abilities to deepen them), creativity and logical-analytical thinking.

It is the complex approach to competence formation, identification of the levels of basic components of engineering competency that methodically and fundamentally distinguishes the suggested application of PBL, which is considered to be an unconventional teaching method, from the common models of the automated teaching systems and computer-based complexes [Гуревич 2006].

Taking into consideration that the structure of engineering disciplines implies every basic component (lecture, laboratory lesson, practical lesson, tutorial, credit and examination), it is reasonable to introduce a three-step implementation of PBL-based methods for acquiring knowledge and controlling over students' mastering the appropriate skills.

Thus, at **step 1** teacher logically provides instructional information via a computer with further testing control over students' theoretical knowledgeability. At **step 2** students' capabilities to apply the acquired knowledge for performing laboratory tasks are checked; here advanced informing and inquiring are interchanged. At **step 3** learners are supposed to obtain essential knowledge and skills for independent solving advanced applied tasks that are similar to those students are likely to face in their real practice; at the same time teacher evaluates their theoretical knowledge and logical-analytical thinking abilities.

In the process of engineering training, students undergo various forms of testing.

1. Evaluation of learners' theoretical qualification consists of at least five control questions, each of them being compiled in accordance with the specifics of machine questioning and allows to check up the minimum fundamental knowledge on the certain section of theoretical course. A student is admitted to the next form of testing provided that he/she can display the minimum admissible knowledge.
2. Evaluation of learners' readiness to perform certain laboratory or practical tasks is grounded on students' answering at least five control questions, which are closely related to the subject of instructional section (to the research objectives, sequence of implementation, physical bases of the processes and phenomena etc.). Thus the level of students' qualification cannot be assessed by the established 100-point scale, since the so-called „half-qualified" students are not admitted to solve laboratory or practical tasks. Consequently, the method of students' qualification evaluation is absolutely different so long as it uses a two-point scale where students get either acceptable or failing grade with the latter forbidding them to carry out laboratory or practical tasks unless then get profound knowledge in the subject area. If students succeed in answering correctly all the control questions, they can start the third stage of testing.
3. Evaluation of students' theoretical qualification is based on the total value of determinants of their creative activity in carrying out individual computing or research cycles within the overall task set for performing a laboratory work or practical task, namely (1) to set objectives for a local research as well as to carry it out; (2) to plan the experiment together with determining the impact of specific features of the research on quantitative-qualitative indicators of its efficiency. The results obtained in parameter optimization, which allow to make up conclusions concerning further refinement of process descriptions, enable to assess learners' creative abilities to solve engineering tasks.

4. Evaluation of learners' logical-analytical thinking is the arithmetical mean value of all the points students get for laboratory and practical tasks they have solved in the course of engineering training. Here taken into account are students' abilities to draw conclusions with regard to the results of the conducted research. Teacher is in charge of devising recommendations for further improvement of instructional methods within PBL.

It is worth mentioning that in order to prevent „predictability" of the content and sequence of control questions offered by PBL-based system, the random number generator method for presenting questions has been devised [Козлакова 2003].

In the course of the experiment, 52 learners participated in the PBL education method while 47 were trained through traditional methods. Their performance was assessed by a 100-point rating scale. The arithmetical mean values are shown in fig. 1.

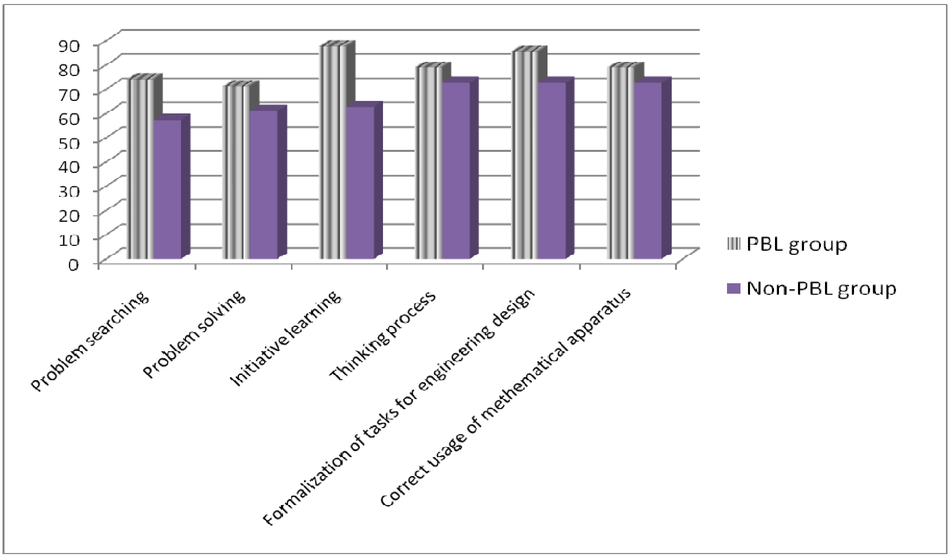

Fig. 1. Comparison of average grades between PBL and non-PBL groups

It is obvious that PBL promotes students' confidence in their problem-solving skills and strives to make them self-directed learners. These skills can put PBL students at an advantage in future courses and in their careers. While such confidence does not come immediately, it can be fostered by good instruction. Teachers who provide a good learning community in the classroom, with positive teacher-student and student-student relationships, give students a sense of ownership over their learning, develop relevant and meaningful problems and learning methods, and empower students with valuable skills that will enhance students' motivation to learn and ability to achieve.

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Abstract

The article deals with the methods for assessments and evaluation of knowledge and professional skills of students' majoring in engineering in the course of their problem-based learning. Offered are the methods for testing and evaluating students' theoretical knowledge, practical skills and logical-analytical thinking. Shown are the results of the experiment, which prove that PBL promotes students' confidence in their problem-solving skills which can be of benefit to their future courses and in careers.

Key words: problem-based learning, assessment, evaluation, control tests, logical-analytical thinking, experiment.

Ocena i ewaluacja przez rozwiązywanie problemów w trakcie kształcenia studentów na kierunkach inżynierskich

Streszczenie

Artykuł dotyczy metod oceny i ewaluacji wiedzy i umiejętności zawodowych studentów na kierunkach inżynierskich w trakcie nauki przez rozwiązywanie problemów. Opisane są tu metody testowania i oceny teoretycznej wiedzy uczniów, umiejętności praktycznych i myślenia analitycznego-logicznego. Przedstawione są wyniki eksperymentu, które dowodzą, że PBL wzmaga pewność studentów w zakresie umiejętności rozwiązywania problemów, które mogą być wykorzystane w ich dalszym kształceniu i rozwoju kariery.

Słowa kluczowe: kształcenie przez rozwiązywanie problemów, ocena, ewaluacja, testy kontrolne, myślenie analityczno-logiczne, eksperyment.