Chapter 16
The Problem-Oriented Approach in the Basic Mathematical Courses for Engineering Education

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ABSTRACT

Problem-based learning takes a well-deserved place in the educational programs of leading universities in the world. Meanwhile it is known that this approach has been well developed for training students of economy and medicine. There are certain difficulties in setting targets as well as in teaching methods in basic technical subjects, in particular in the mathematical courses. The chapter presents an analysis of the peculiar features of problem-based learning in a research university for basic courses of the first two years of study. The discipline "Numerical Methods and Mathematical Modeling" is given as an example of the application of this approach. The main topics are proposed and lesson plans are provided. The information support of the courses is carried out in the learning management systems. The elements of this approach have been put into practice of training course and it was shown that the material was achieved much better.

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ORGANIZATION BACKGROUND

Tomsk State University (TSU), located in the south of Western Siberia, opened in 1888 as the first university in Russia behind the Urals. There are 22 faculties, three institutes of applied sciences, the scientific library, and the Siberian Botanic Garden. In 2016, TSU was listed as one of four leaders in the Project 5-100 in Russia. In addition, the university continues to improve its position in the world rankings of institutions of higher education.

INTRODUCTION

PBL takes a well-deserved place in the educational programs of leading universities (Barrett, 2010; Cotič, & Zuljan, 2009; Mertins, 2012). It can be a challenge to develop teaching research students' independent learning skills and transformation of reality (Hung, 2011; Schmidt, Rotgans, & Yew, 2011). The creative portion of the learning process includes the research of new facilities, storage of acquired knowledge, and identification of task and method solutions. Students develop and show personal competences, including original thought, problem recognition, quick orientation in new conditions, and intuition in the process of solving creative nonstandard tasks. PBL meets the full requirements of modern engineering education. It can be used as a means of developing trainees' learning activities and independence.

The basic concept of PBL is an educational problematic situation. PBL is a complex theoretical or practical question. It contains a latent contradiction and, upon solving, leads to different (and often opposing) viewpoints. PBL is a mental state (or cothinking interaction) of a student or group of students under the guidance of a teacher.

This chapter will elucidate the peculiarities of applying the problem-oriented approach in teaching mathematical disciplines. It will also describe the use of PBL in the Numerical Technique and Mathematical Modeling course during the second year of the radiophysics faculty engineering specialty (Radio Electronic Systems and Complexes) at National Research TSU. The chapter will provide main topics and lesson plans. It will analyze problems encountered by participants and teachers during the educational process. The conclusion will discuss the implementation of PBL elements.

BACKGROUND

This approach has been successfully developed to educate students in the fields of economy and medicine (Iskrenko & Poulton, 2008; Spencer & Jordan, 1999). A review of the references shows that PBL has been widely used in medicine. Recently, this approach had made spectacular progress in engineering education. However, there are limited methodological developments in educational disciplines, including mathematics (see Figure 1). Figure 1, which is based on data from the international citation database Scopus, shows a nine-year containing publications and key words.

Articles focusing on PBL in both exact sciences and engineering contain, as a rule, a description of the experience of applying this method in a university and for a specific subject. During the last two years, some articles reviewed existing developments and offered generalizations of experiences (Merritt, Lee, Rillero, & Kinach, 2017).