Expert assessment of mathematics teaching abstraction level

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Conference Key Areas: Mathematics and Engineering Education, Engineering Education Research

Keywords: abstraction level, mathematics, engineering education, expert seminar

INTRODUCTION

The basis of higher education is a fundamental education providing students with the opportunity to learn the basic laws of nature and society development, forms the ability to logical reasoning. Graduates should be able to analyze and classify the facts, make decisions and apply a scientific approach to the study of phenomena, events and processes.

Undoubtedly, mathematics is the discipline laying a fundamental for the entire spectrum of Sciences, Technology, Engineering and Mathematics (STEM) curricula. Successful development of the world science in modern conditions is closely related to the use of the entire arsenal of mathematics to solve fundamental and applied problems.

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The high level of abstraction, the lack of close link between the material presented in the lectures on mathematics to the future professional activity leads to a sharp decrease in the motivation of studying this discipline. Students believe that learning outcomes of studying mathematics is abstract knowledge, rather than skills and practical competencies for solving professional problems. Failure to understand the value of the information obtained, misunderstanding of the importance of mathematical education for future professional development, lack of interest from school mathematics has a negative influence on motivation and process of studying mathematical disciplines at university [1].

Russia joined the Bologna process in 2003. But, similarly to other countries the introduction of new educational standards faced serious concerns and opposition from the side of academic community, especially in the STEM domain. It took several years to start taking practical steps towards implementing Bologna principles. Despite the progress, on the grass root level the teaching staff still faces difficulties in adjusting traditional teaching practices to the new frameworks. Inside the country the solid best practice is lacking, therefore the international experience exchange and coaching can significantly help in making the transition faster.

1 METAMATH TEMPUS PROJECT

In the last twenty years, both new demands of the engineering profession and inadequate mathematics ability of the engineering students have led in a big change in the scope of the mathematics education. The recent developments in technology and computers have caused variation in teaching mathematics of engineering students and have brought with them the use of modern techniques and methods [2]. The majority of above mentioned problems are addressed in the MetaMath Tempus Project (Modern Educational Technologies for Math Curricula in Engineering Education of Russia) [3] in which Association for Engineering Education of Russia (AEER) takes part as the Consortium member.

The overall objective of the project is to improve the quality of STEM education in Russia by modernizing and improving the curricula in the field of Mathematics. The process of modernization will start from the fundamental revision of the way math studies are organized in all Russian universities offering degrees in STEM. After ensuring the consistency of the math curricula with the Bologna principles and best European standards, the further steps will be taken to modernize the content and teaching methods by introducing principles of blended learning and new educational technologies.

Specific objectives of the project:

- To implement a comparative analysis of the national math curricula for engineering and science studies in order to define the recommendations for structural improvements in line with the Bologna principles. To identify the areas most suitable for the introduction of TEL tools.

- To modernize math and statistics curricula for a selected set of engineering and sciences studies. To select the necessary math & statistics eLearning content to be used for modernization.

- To localize the European TEL tools for partner universities, including TEL content localization. To build a capacity in local universities to effectively implement, maintain and develop TEL for math education.

- To implement a pilot trial in order to practically introduce the modernized curricula into the academic process. To evaluate the impact of the new curricula on quality of

studies in math and statistics, as well as on quality of engineering and sciences education in general.

- To spread the results of the project.

2 AEER RESEARCH

Analysis of the abstraction level of mathematics teaching in engineering HEIs has become the main topic of a study conducted by the Association for Engineering Education of Russia (AEER) following the MetaMath Project goals. The paper presents main results of the pilot expert seminar hold in March 2015 with participation of Tomsk Polytechnic University (TPU) undergraduate students.

2.1 Method

Expert seminar was used as a main method at this research which represents a set of generally known, but systematically and purposefully organized teaching and learning methods corresponding to the principles of problem-based approach. During expert seminar participants are encouraged to work individually or as team members following the main steps as shown in the Fig. 1.

The proposed learning method is delivered in the form of seminar, where participants act as experts in particular field of knowledge and are invited to gradually investigate (analyze) the problem and suggest solutions. Therefore, this method is called "Expert Seminar" [4,5]. Such approach requires active work from each participant who feels responsibility and trust given to him/her as an expert.

2.2 Participants

Expert seminar focused on assessment of mathematics teaching abstraction level was hold among undergraduate students from 3 TPU elite education groups. The total number or participants who took part in the seminar was 36. Those were students of different educational programs in the field of engineering and technology who attend math classes as part of specially selected elite groups.
The goal of the elite engineering education system (introduced in TPU in 2004) is to train professionals of an absolutely new level that are capable of making a complex combination of research, project, and entrepreneurial activities, possess deep fundamental knowledge, have a good grip of engineering creativity, and are able to work in a team.

During the training process a student must acquire:

1. In-depth knowledge of fundamental sciences (mathematics, physics, economics).
2. Profound professional competencies.
3. Competencies in the area of engineering entrepreneurship that include project work, engineering invention, innovation theory, and market knowledge.
4. Fluency in English language.
5. Leadership and teamwork skills through forming a learner-centred educational environment in the process of training.
6. A holistic worldview and form a complex value thinking [6].

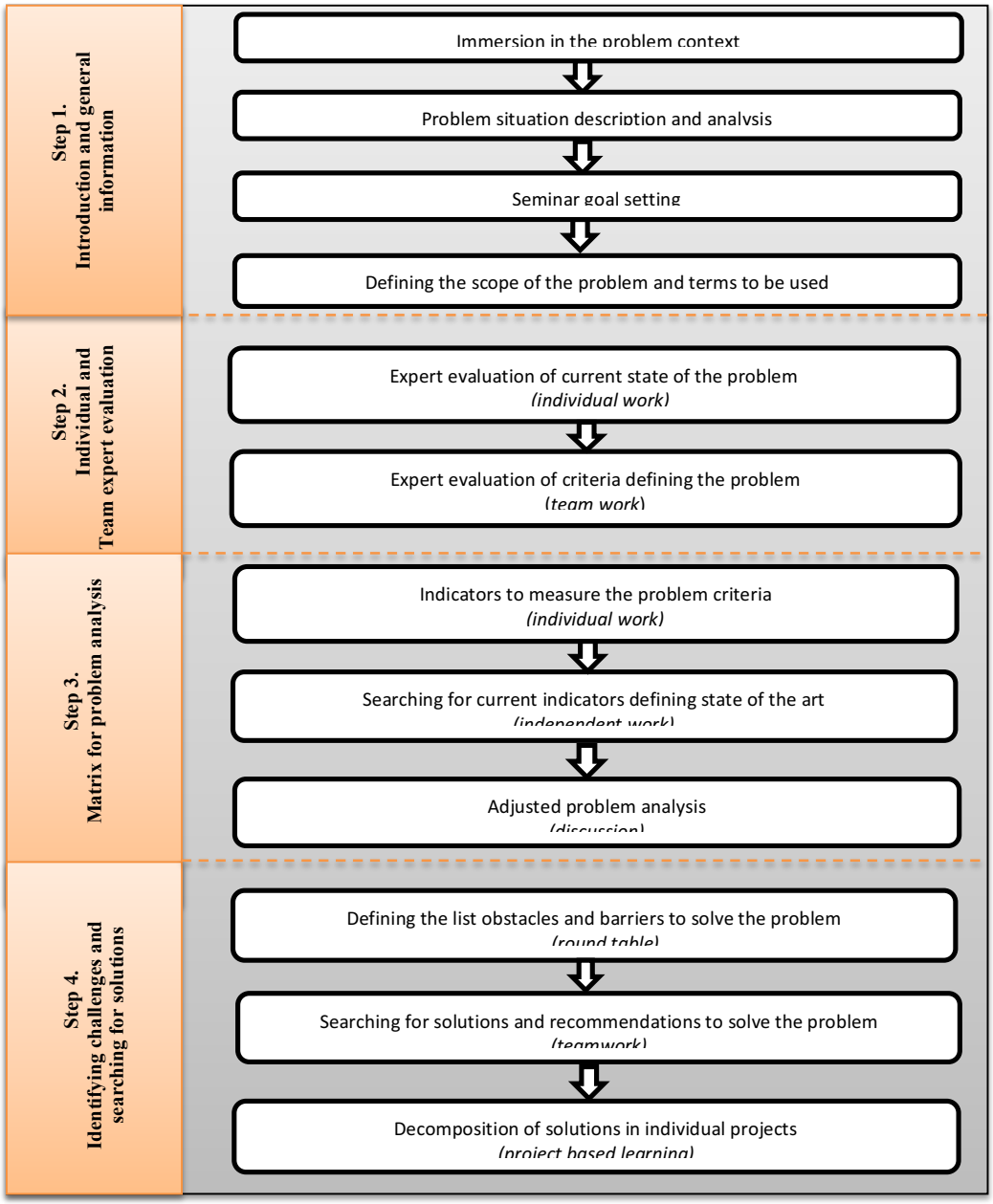

Fig. 1. Expert seminar structure

2.3 Results

Students acting as the experts were challenged to analyze and assess the level of abstraction of mathematics teaching in the engineering HEI; develop criteria of assessing the level of abstraction of mathematics teaching; fill in the matrix evaluating the abstraction level of teaching mathematics; identify obstacles to make teaching of mathematics less abstract; propose the necessary changes in the organization of training engineers to reduce the abstraction of mathematics teaching.

At the first stage participants of the seminar were asked to give individual assessment of mathematics teaching abstraction level in engineering HEI based on their personal experience and expert opinion. Students had to choose from the list of rates:

- critically low;
- low;

- acceptable;
- high;
- totally abstract;
- other opinion.

According to the obtained results most students estimate the level of abstraction of mathematics teaching as an acceptable or high, 48% and 40% respectively. Only 8% believe that the level of abstraction is low, while 4% consider it totally abstracted as shown at Figure 2.

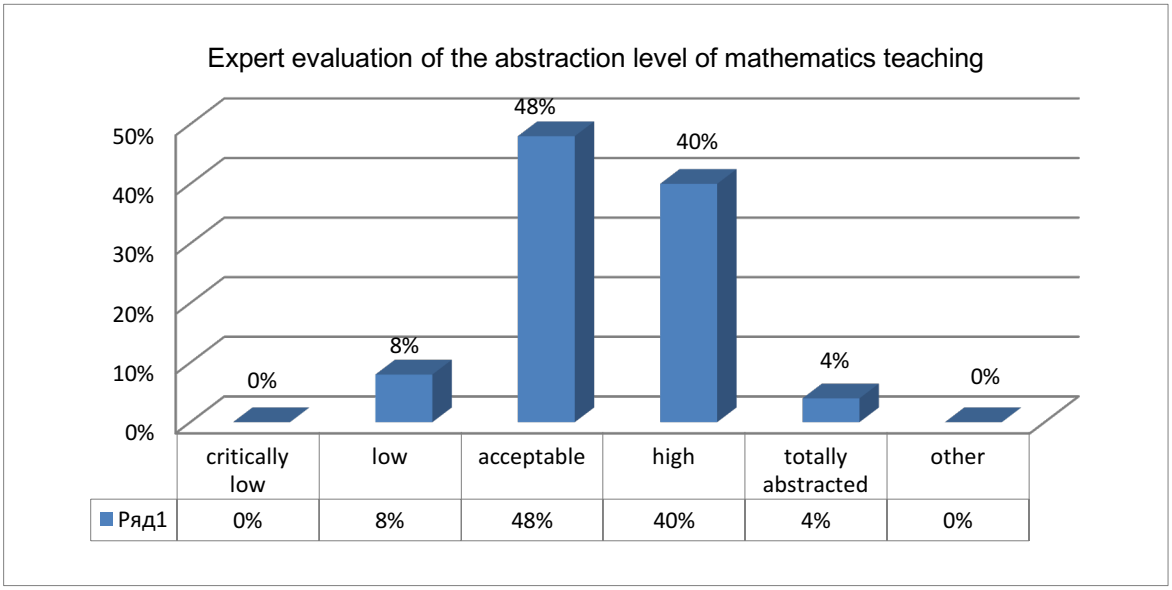

Fig. 2. Expert evaluation of the abstraction level of mathematics teaching

While working in teams students listed the following criteria to define the abstractness of mathematics teaching in engineering HEI:

- number of theoretical topics (lecture classes) advancing practical exercises;
- share of real examples from engineering and technology;
- share of theoretical classes;
- share of practical training;
- the percentage of introducing and implementing models and patterns to ensure clarity and visual expression.

Among the major obstacles to make teaching of mathematics less abstract experts outlined:

- a small share of practical training;
- timetable of classes;
- insufficient number of guidelines;
- insufficient number of learning hours for the subject (a lot of information);
- inapplicability of certain tasks to the reality;
- lack of analogies, lack of systematization of educational material.

Students acting as the experts suggested several recommendations how to change organization of mathematical training of engineers to reduce the abstraction level:

- development of a larger number of learning guidelines and handbooks (systematization of methods and algorithms) convenient to use (e-learning tools);
- continuous professional development of teachers;
- more appropriate timetable and sequence of learning activities;
- opportunity to follow individual learning plan (choice of courses).

3 SUMMARY

According to ENQA, the role of students in the quality assurance of higher education has become recognised, across Europe, as being both necessary and desirable. Students have increasingly become involved in the improvement and enhancement of their own learning experiences [7]. Of course, educational program managers cannot totally base on the students' opinion when making decisions how to improve the quality of education. However, taking into account concepts of student-centred learning, academic community should not ignore them.

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