An active learning approach to teaching mathematics at Kaunas University of Technology

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Abstract

The paper presents some active learning methods applied to the study process of engineering mathematics at Kaunas University of Technology (KUT). Promotion of active learning techniques in teaching mathematics at KUT was launched a few years ago, following the decision of the university authorities to implement active learning strategies (with the use of ICT facilities) in organizing tutorial classes in mathematics throughout the university. Therefore eleven specialized classrooms for teaching mathematics have been equipped at KUT.
In the paper, applications of active learning methods are discussed. During tutorial classes, mathematics software and interactive means are available. Students are enforced to change from passive listeners to active learners. To prepare teaching material, to promote active learning in discussion sessions, to monitor the study process, to interact between students and lecturers, to support brief question-answer sessions, a virtual learning environment WebCT and EDU Campus System are used.
Some advantages and weaknesses of the implemented active learning methods are presented too.

Introduction

Involvement in engineering studies in Lithuania has decreased considerably in the last few years. The majority of school-leavers prefer social or business studies at the university level rather than engineering studies. Every year more and more gifted school-leavers give priority to social or business studies and it means that the mathematical knowledge of first year engineering students at KUT (and not only!) fall gradually down. The first year engineering students cannot answer the theoretical questions during various tests on mathematics, because the secondary schools do not pay much attention to the theory of mathematics - they focus mainly on solving practical exercises. The results of first semester exams at KUT in 2002-2003 showed that nearly 30 percent of all first year students passed an exam in mathematics on their first attempt (Table 1). After some additional preparation (and several attempts) the percentage increased to 62. The rest of the first year students dropped out from the university or took the course on mathematics repeatedly, because they did not reach the required standard (the SEFI MWG recommendations for technical universities (Mustoe & Lawson (2002)) in a prescribed time period.

Summing up the situation, the university authority has decided to improve the curriculum of mathematical studies and the quality of the teaching process itself by introducing the following activities:

- Implementation of active learning strategies (using IT facilities) in order, and organizing tutorial classes on mathematics.

- Expansion of the usage of mathematical software in the study process of mathematics.
- Application of virtual learning environments in order to make teaching and learning of mathematics more student-friendly.
- Providing students with the opportunity to study themselves, to test their knowledge on mathematics, to develop their mathematical abilities.

Faculty	The number of first year students	Successful ''passes'' (first attempt)		Successful ''passes'' (after first and repeated attempts)	
Computer science	489	183	37,42%	362	74,03%
Telecommunications and Electronics	259	111	42,86%	196	75,68%
Electrical and Control Engineering	244	54	22,13%	130	53,28%
Chemical Technology	220	67	30,45%	125	56,82%
Civil Engineering and Architecture	139	20	14,39%	81	58,27%
Art and Design Engineering	275	75	27,27%	152	55,27%
Mechanical Engineering	328	28	8,54%	112	34,15%
Social Sciences	249	47	18,88%	147	59,04%
Economics and Management	233	91	39,06%	191	81,97%
Fundamental Sciences	150	87	58,00%	115	76,67%
Total	**2586**	**763**	**29,51%**	**1611**	**62,30%**

Table 1. Mathematics exam outcomes (First year students at Kaunas University of Technology; autumn semester, 2002-2003)

Learning environment

The aim of an active learning environment is to maintain and encourage students' motivation to learn, to make them feel confident and ambitious during their studies (Jonassen & Land (2000)). The active learning environment at KUT was built according to the following principles:

- Students have to demonstrate active performance in their studies, i.e. they are not encouraged to gain their experience only from the books or sources provided by university.
- Some part of tedious mathematical calculations during tutorials should be replaced with calculations using appropriate mathematical software. Every time, attempts should be made to separate mathematics, which does not require much understanding and which can be done with the computer, from mathematics, which requires deep understanding and careful studying.
- Activeness of students should be increased by applying interactive approach (Croft & Davison (2004)).
- Students should be taught to solve real life problems and should understand that learning of mathematics is important and will benefit them in the future.
- Lecturers should encourage students to give feedback about their studies.
- Discussions on the matter should be organised, because they not only motivate students to be more active in their studies, give them an opportunity to develop

various theoretical and practical skills, but also this is a very effective feedback (MacKnight (2000), Crouch & Haines (2004)).

To achieve the goals of the active learning environment, 11 mathematics teaching classrooms were set up. Each classroom was equipped with 25 computers and the Internet connection, mathematical software and audio-video devices. This environment was created on interactive learning basis, which is focused on the learner-centered approach.

Mathematical software. For the basic mathematical courses, which are provided in the computer classes, the mathematical software MathCad has been chosen. First of all, the MATHCAD script is very similar to one used in the mathematical textbooks and, consequently, can be easily accepted by the students.

To say more, using MATHCAD it is possible to write a text, formulae, perform interactive calculations, use plots and diagrams, etc., i.e. easily create "live" electronic books. MathCad also has advanced features for document processing, which allow you to create complex mathematics documents faster and easier than using a word-processor or LaTeX.

MathCad software is used to create electronic tutorials - worksheet sample problems and solutions. These tutorials cover all major topics on mathematics. Students can easily edit these worksheets (change parameters, tables, graphs) and adapt them to solve standard and non-standard mathematical problems on differential equations, linear algebra, probability, statistics, etc. Using MathCad worksheets helps students to gain more knowledge and experience in mathematics and maximizes benefits of the course.

Obviously, technology-based learning materials have to be transparent and enable their users to inspect, test and modify them (Kadijevich, Haapsalo & Hvorecky (2005))**.** MathCad worksheets contain these features. In the opinion of many students using MathCad this software makes learning of mathematics easier and more attractive.

A virtual learning environment (VLE) WebCT. Students can access the course materials during and after the computer-based tutorial classes using WebCT. During the tutorial classes, students use a wide range of interactive websites designed for learning mathematics and statistics. There exists a wide range of websites focused on learning mathematics, which can be perfectly used in mathematics tutorial classes. WebCT is used for distance and face-to-face teaching. Students can always be in touch with the latest information if they have missed a class: all handouts and course related information can be found in the WebCT website. For instance, using WebCT students can find videos (created and uploaded using software VIP - product of KUT) of lectures from the course "Probability theory and statistics". WebCT also provides many links to additional mathematical resources for students, who need extra support. WebCT is mainly used for the preparation of learning materials for various mathematical courses, for promotion of active learning using discussion sessions, monitoring the study process and interaction between students and lecturer.

The virtual learning environment (VLE) enables students to work at their own places and invites them to pay more attention to things which need more knowledge and practice than others. University staff and students evaluate the WebCT positively and point out many benefits of VLE. Factors increasing motivation of students are as follows: more relevant module content, additional support, some schedule changes, new assessment schemes, more intense use of ICT.

We agree with the point that "The class-based tutorials are the cornerstone of the well-prepared mathematical courses. It is only a little possibility that at present or in the near future, such tutorials can be efficiently replaced by the on-line tutorials. Many features of the traditional "face-to-face" teaching cannot be properly implemented in WebCT" (Foster (2003)).

Simulation exercises. Integration of simulation into the learning process breaks the gap between the theory and real life problems, explains and demonstrates how real life processes can be transferred to mathematical models. Simulation is used for developing logical thinking and problem solving skills. By combining simulations with assessment technology the same tools can be used for learning and assessment. This can be particularly beneficial where learning outcomes require more than the demonstration of knowledge (Thomas & Ashton (2005)).

The interactive simulations provide students with a better understanding of more difficult problems. For instance, consider the influences of extreme observations on the regression line of a particular data set. Using an applet, one can see the effects of the extreme observations to the regression line.

It is the usual thing that students often have to master theory (e.g. regression analysis) before they start using its outcomes. In order to avoid such confusing and demotivating practice, technology should be used continuously along learning paths, provoking further learning of mathematics. On the other hand, when technology produces inappropriate results it is a great opportunity to gain more knowledge of the applied tool (MacKnight (2000), Crouch & Haines (2004)).

Assessment methods. WebCT and EDU Campus System (EDU Campus (2007)) are used to support of brief question-answer sessions, self-assessment and assessment during the semester. The assessment methods, currently available in WebCT and other VLEs, are not adequate for all mathematical courses. Multiple choice and similar types of questions do not test adequately basic mathematical skills, which are compulsory for students to progress satisfactorily in mathematics courses (Foster (2003)). Therefore the EDU Campus system was chosen for the creation of the active learning environment. This software has few shortages assessing the students compared with WebCT and many other tools. EDU campus system allows building of assessment documents with MathML 2.0, Maple, LaTex or WebEQ. Questions then can be exported to WebCT. EDU campus system maintains a wide range of question types: multiple choices, multiple selection, short answer, fill-in-the-blank or clickable image. Clickable image questions present an image with a number of "hotspots", and students are required to

identify the correct image element by clicking on the corresponding hotspot. Lecturer can combine these question types within a single question depending upon the complexity of the concept tested and intent of assessment. EDU Campus can automatically generate content in any of its question types. EDU supports several Applet Interaction Questions.

Use of computer aided assessment system consolidates students' learning and learning results. Students at KUT gain their final grade in Mathematics by taking appropriate computer tests (70 %) and passing theoretical exam (30 %).

The influence of the active learning approach on the study results

Applying mathematics software, virtual learning environment and active methods to teaching and learning of engineering mathematics at KUT during the last five years (from 2002 to 2007; Figure 1) increased the number of students, who succeeded in getting a "pass" on time, by 27.1 percent, i.e. from 29.5 percent (the entrance year 2002) to 56.2 percent (the entrance year 2007).

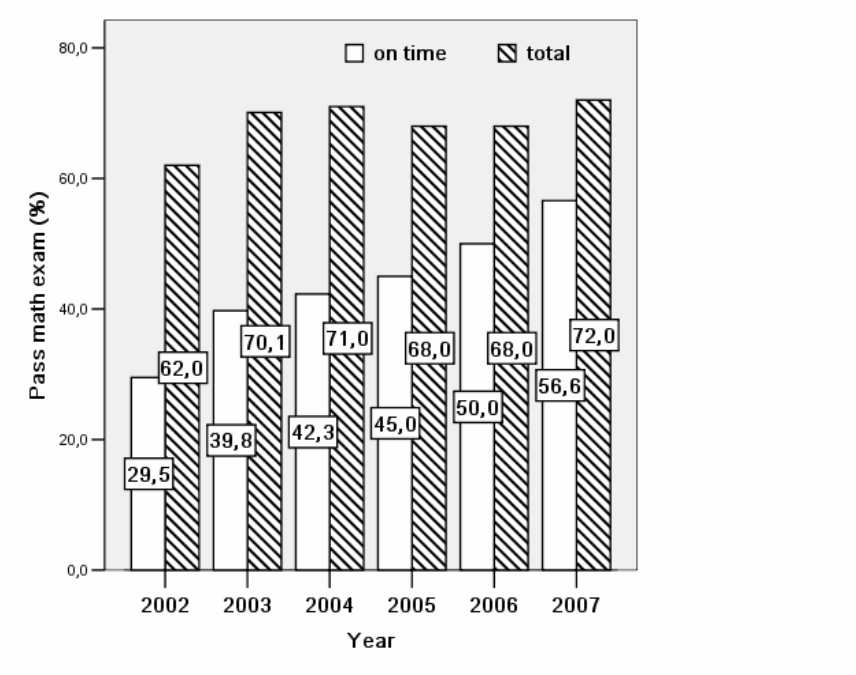

Figure 1: Distribution of successful ''passes'' mathematics exam (first attempt-on time) and successful ''passes'' after first and repeated attempts (total).

The total number of first year students passing exams (on time or repeated attempts) remained unchanged (70%). Additional analysis is needed to answer the question – why 30% of first year students are unable to pass mathematics exam?

Conclusions

Using the active learning environment undergraduate students are more involved in the learning process, their learning outcomes evidently improve. Some advantages of the discussed learning environment are listed below:

- It facilitates and improves students' understanding of basic concepts (through the use of new instructional materials).
- It provides students with a flexible learning medium.
- It provides students with individualized feedback and common interface, both being helpful and intuitive.
- It provides support to faculty and students in developing and expanding diversified mathematical materials.
- It facilitates monitoring of the student progress.
- It develops a more positive attitude towards learning mathematics.

Among the weaknesses of the environment we mention the following ones:

- Lecturers of mathematics are forced to develop additional problem-oriented material for the active learning of students. Because of rapid changes in the mathematics software development, the used learning material should be permanently updated.
- Some of mathematics lecturers do not have sufficient ICT knowledge and skills, so they cannot realise the real power of computer-based modelling. It keeps down further implementation of ICT in the study process.
- It takes more time to write mathematical expressions using computer's software in comparison with hand-writing.

References

Mustoe, L. and Lawson, D. (2002) *Mathematics for the european engineer: A Curriculum for the Twenty-First Century*. A Report by the SEFI Mathematics Working Group. Published by SEFI HQ, Brussels.

Jonassen, D.H. and Land, M.S. (2000) *Theoretical Foundations of Learning Environments*. New Jersey: Lawrence Erlbaum Associates Publishers.

Croft, A.C. and Davison, R.(2004) *Mathematics for Engineers - a modern interactive approach (2nd edition)*. Addison Wesley Longman.

Kadijevich, D., Haapsalo, L. and Hvorecky, J. (2005) Using technology in applications and modelling. *Teaching mathematics and its applications*, 24, No. 2-3: 114-122.

MacKnight, C. B. (2000) Teaching Critical Thinking through Online Discussions. *Educause Quarterly*, 23(4): 38-41.

Crouch, R. and Haines, C. (2004) Mathematical modelling: transitions between the real world and the mathematical model. *International Journal of Mathematical Education in Science and Technology*, 35: 197–206.

Foster B. (2003) On-line teaching of mathematics and statistics. *Teaching mathematics and its applications*, 22, No. 3: 145-153.

Thomas, R. and Ashton, H. (2005) "Use and Reuse of Simulations in Mathematical Online Assessment, LTSN MSOR Maths CAA series". Accessed via http://mathstore.ac.uk/articles/maths-caa-series/july2005/ (6 February 2008).

EDU Campus (2007). Accessed via https://www.brownstone.net (10 January 2008).

5. Impact of technology on Teaching & learning Mathematics. Researchers have found that the move from traditional paper-based mathematical notations to on-screen notations (including algebraic symbols, but also graphs, tables, and geometric figures) can have a dramatic effect. In comparison to the use of paper and pencil which supports only static, isolated notations, use of computers allows for â€œdynamic, linked notationsâ€ with several helpful advantages.Â In combination, these features can enable teachers to integrate project based learning. Calculators and other technological tools, such as computer algebra systems, interactive geometry software, applets, spreadsheets, and interactive presentation devices, are vital components of a high-quality mathematics education. The article deals with the CLIL technology as an innovative method of foreign languages teaching in higher education. Current social, political and economic background demands introducing integrated approaches to the higher education system in order to train future specialists capable of intellectual flexibility and integrated task solution. The paper touches upon the history and the methodological peculiarities of the technology, benefits of its implementation in higher education; suggests CLIL activities that might be used at language classes; highlights the difficulties the academic staff m