Opportunities of Studying Engineering in Latvia University of Agriculture with Low Basic Knowledge in Mathematics

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Abstract: Mathematics in engineering studies is one of the basic subjects not only providing the knowledge of the calculations for different processes, but also developing cognitive and problem-solving skills. At the same time, mathematics is one of the subjects causing a large number of dropout students in engineering programmes. It is not a secret that one of the reasons is insufficient secondary school level mathematical knowledge. In order to increase the opportunities for students with insufficient knowledge of secondary school level mathematical knowledge to study engineering, the research was carried out in the Department of Mathematics of the Latvia University of Agriculture (LUA), in which, firstly, the test was organized on mathematical concepts, secondly, the correlation was calculated between the grades of the centralized secondary school exam in mathematics and, thirdly, mathematical concepts receiving the lowest results were identified. As one of the possibilities to improve mathematical knowledge, remedial mathematics courses were offered to students. The other option was the design of summaries of the necessary mathematical topics and the creation of a reference to the summary of each specific topic of higher mathematics. Higher mathematics entitles students to solve individual tasks; therefore students have an opportunity to use the teachers' advice for solving individual tasks twice a week. Results of the research showed their attitude of students towards the use of the possibilities offered as well as a correlation between attendance of the remedial course and the results of studies in mathematics.

Keywords: higher education, students' independent studies, individual work, IT tools, e-studies.

Introduction

The Bologna Process was introduced in the member states of the European Union in 1999 with the aim of creating a European Higher Education Area. Existing evidence on the impact of the Bologna reform on higher education enrolment and drop-out rates is limited. The introduction of the Bachelor degree has no significant impact on enrolments or drop-out rates for most subjects, however, significantly negative effects of the Bachelor implementation on enrolments for the subjects of electrical, mechanical and industrial engineering as well as for physics (Horstschräer, Sprietsma, 2010).

The Bologna process suggested that having shorter time for obtaining degrees would result in decreased dropout rates. While there has been a decrease in dropout rates in the humanities and language programmes, this has not been the case in the mathematics programmes. For example, it was found that in Germany, in mathematics (and mathematics-related fields) there was an increase in dropout rates. Currently, about 20% of students who begin a program fail to complete it; however, for students of mathematics-related fields, that number jumps to more than 30% (Fox, 2010). Also at the Latvia University of Agriculture (LUA) more than 30% of students from engineering specialties drop out just after the first year of studies in which mathematics is one of the basic subject.

Mathematics is a background discipline for specialists who work in many fields of any industry, especially in engineering. The content of mathematics for universities is determined by the European Society for Engineering Education (SEFI) (Booth, 2004). Mathematics is not only the basis of other subjects, but also it is a tool for analysing and solving problems that occur in the world at large. Many specialists see mathematics as something which co-exists with other areas of knowledge and supports the study and development of that knowledge.

Research results of several authors indicate that mathematics in schools and universities does not always provide a solid foundation of knowledge and skills for further studies. Mathematics often

contains a consecutive amount of facts that must be memorized and reproduced. It is a fact that often the so-called "school mathematics" and mathematics needed in different life situations are not related (Zeidmane, 2011). Some important factors that affect the development of mathematics' education in universities should be mentioned. First, there is a demand for highly qualified employees. Second, the content of mathematics course has not changed for many years, although the number of ECTS has reduced. Third, there is an increase in the number of students who have insufficient knowledge of natural sciences and poorly developed cognitive abilities. The problem in mathematics study process is students' disability to make a long chain of logical conclusions in order to acquire large pieces of information. Students would like mathematics to be more understandable and more suitable for practical use in adult living (Balciunas, Macaitiene, 2011).

In the 17th SEFI seminar, "Mathematical Education of Engineers" it was noted that many beginners in mathematics, natural and engineering sciences as well as in economic sciences have big problems starting their studies because of their lack of mathematical competencies. Thomas Schramm (Schramm, 2014) pointed out, "Neither ignoring nor waiting for better students' help, nor one-week preparatory crash courses. So, a lot of different programs are under way to mitigate the situation. Since we all have the same problems there is a high potential for concentration, standardization and most important for cooperation." The seminar offered some solutions. The TU9, the German association of nine technical universities, decided to support a project building up an online-eLearning platform on the basis of this common standard including a self-assessment of the students. In Baden-Württemberg colleagues from schools and universities developed a catalogue which defines the minimal standard of mathematical skills needed to begin the above mentioned study programmes.

Similar problems are also faced by the Latvia University of Agriculture, in particular, engineering study programmes. In order to fill state-financed places, the university should admit students with unsatisfactory mathematical background knowledge.

The aim of this research was:

- to investigate the current situation at the Faculty of Information Technology of the LUA, to determine the real level of mathematical knowledge, organizing the test for the 1st year engineering students on secondary school level in mathematics, identifying topics in mathematics with lowest results;
- to find the way to provide assistance and support to students with insufficient secondary level mathematical knowledge;
- to evaluate the effectiveness of the solutions proposed by analyzing the results in mathematics, as well as the student's opinion.

Methodology

The problem of dropout students is topical not only in the universities of Europe but also around the world. Already in 1971 the University of Chicago developed the theoretically based model of the Undergraduate Dropout Process (Spady, 1971). The model as operationalized represents a synthesis and extension of concepts pertinent to balance theory, D.E.Durkheim's (Durkheim, 1982) theory of suicide, and the work on college dropouts. It regards the decision to leave a particular social system as the result of a complex social process that includes family and previous educational background, academic potential, normative congruence, friendship support, intellectual development, grade performance, social integration, satisfaction, and institutional commitment (Figure 1).

Although social integration, satisfaction, and institutional commitment can be explained primarily on the basis of the intrinsic rewards associated with intellectual development, the dropout decision is largely influenced by extrinsic performance criteria among the men but less so for the women.

Nowadays, the research is devoted to both the reasons for students leaving full-time undergraduate programmes and online programmes. Students reported leaving the program for a variety of reasons. Their reasons for leaving the online programme were organized into personal, job-related, and program-related reasons (Willging, Johnson, 2009):

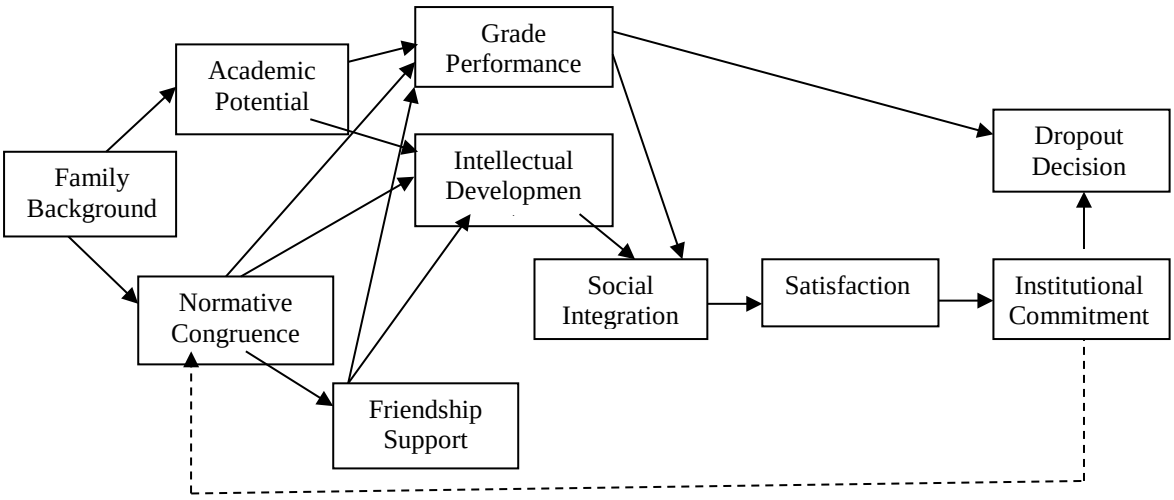

Figure1. Theoretically Based Model of the Undergraduate Dropout Process.
(author adapted from Spady, 1971)

- Personal reasons:
  - financial difficulties or the long-term financial investment not worth the benefit;
  - lack of time to complete the assignments, which took more time compared to traditional courses;
  - schedule conflicts;
  - family problems;
- Job-related reasons:
  - job responsibilities changed during the program;
  - their company didn't support the program;
  - too hard to work full-time and be a student in an online course;
- Program-related reasons:
  - too many low level assignments;
  - too difficult working on the group assignments;
  - lack of one-to-one interaction with the instructors and students;
  - the academic program was too difficult / demanding;
  - lack of interest in the material or the program didn't meet expectations;
- Technology-related reasons:
  - the learning environment was too de-personalized;
  - not enough support from the technical staff;
  - the technology overwhelmed the content;
  - lack of technical preparation for the program.

As regards the Latvia University of Agriculture, the largest number of dropouts happens in the first year. In order to reduce the number of dropout students, the Faculty of Information Technology carried out the survey among students during the first semester once a month. The results showed that that many students had chosen specialty in the last moment and knew very little about the chosen profession.

The research was carried out in the Department of Mathematics of LUA. The analysis of the achievement of 94 first-year "Computer Control and Computer Science" and "Information Technologies for Sustainable Development" study programmes students in mastering "Mate-1" course was carried out.

The following methods of research were used: the survey, descriptive statistics and correlation analysis with Spearman', Pearson' and Kendall's coefficients.

Results and discussion

In order to increase the opportunities to study engineering with insufficient secondary school level mathematical knowledge, the research was carried out in the Department of Mathematics of the Latvia University of Agriculture. The test was organized on elementary mathematical concepts. The test results of students from the Faculty of Information Technology are shown in Figure 2.

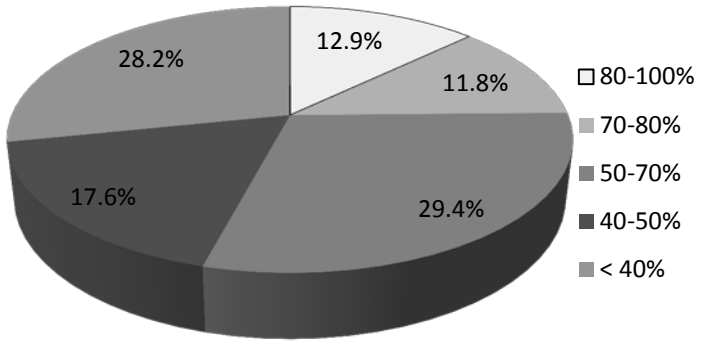

Figure2. Test results on elementary mathematical concepts of students from the Faculty of Information Technology.

The results show that only 24.7% of the first-year students have received more than 70% of the assessment score. It is disturbing that more than 45.8 % of students have received less than 50% score. This means that their mathematical knowledge is unsatisfactory. The secondary schools mathematics course contains a lot of complicated topics and students on completion of the secondary schools are supposed to take the centralized examination in mathematics. Thus a correlation was made between the results of the test on elementary mathematical concepts and the grade in the centralized secondary school exam in mathematics. There was a positive significant ($p = 0.01$) correlation between the results of the LUA test on elementary mathematics concepts, the grade in centralized secondary school exam in mathematics $r_p = 0.82$ and the grade in mathematics in secondary school $r_s = 0.65$ (Table 1).

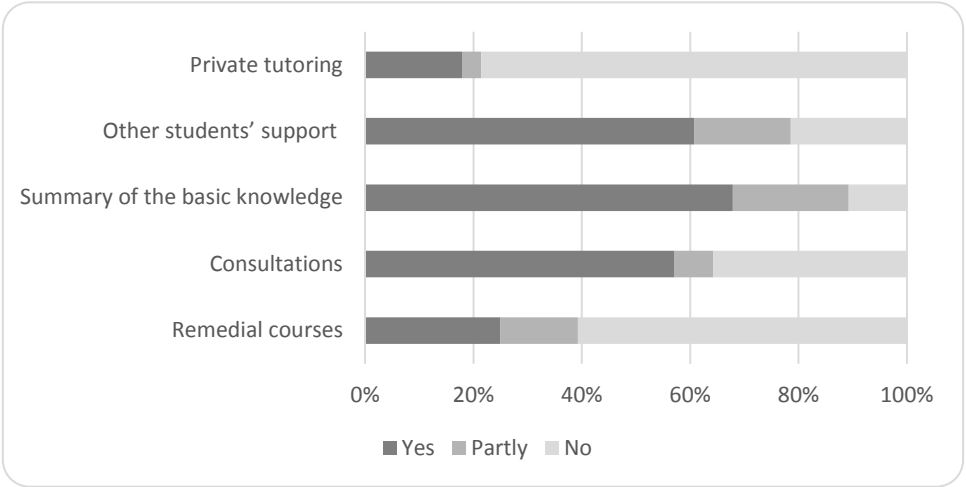

Figure 3. The students' opinion regarding factors helping to improve their mathematical knowledge and achieve higher level of mathematics.

As one of the possibilities to improve the mathematical knowledge, a remedial mathematics course was offered to students. Students with unsatisfactory test results, especially those with the test score less than 50%, were supposed to attend it. Unfortunately, the students' interest in these courses was very low, only 25% attended the course, as it is shown in Figure 3 (mode = median = "No"). Apparently, the students looked for the easiest and quickest ways to improve mathematical knowledge. The other option was the design of the summary of the necessary mathematical topics by

the department staff. The survey results showed that students noted most frequently the possibility of using the summary of mathematical topics for improving their knowledge of mathematics (mode = median = ”Yes”). Students also had the opportunity to attend tutorials where revision of the secondary school mathematical topics was provided in addition to the current material to support students. Tutorials and other students’ support were important to acquire a higher level (mode = median = ”Yes”). Some of students used private tutoring options (mode = median = ”No”).

In order to enhance students to acquire higher mathematics successfully, much attention was paid to the improvement of the study process. In addition to compulsory lectures and practical work, theoretical materials as well as the summary of the main concepts and problem solving techniques in e-environment for students were offered. Studying mathematics students need to solve individual tasks therefore students have the opportunity to use teachers’ advice for solving individual tasks twice a week. The computer algebra program MathCad is integrated in the mathematics study process. Students must check their solutions of individual tasks step-by-step with Mathcad programme in the computer classes. Step-by-step examples of practical mathematics problem solutions with MathCad were designed in e-environment. Students admitted that task solution examples in Mathcad helped to solve the independent work step-by-step, because 1) the results were comparable, 2) solution process of examples in MathCad is similar with the practical task solution on paper. In order to acquire material better, theory tests were offered in e-environment as well.

The results of the survey “What helped to acquire mathematics study course?” showed that students considered that practical exercises and solutions for individual tasks had the greatest significance for studying higher mathematics though they did not underestimate the importance of lectures as well (mode=median=”Yes”). The summary (didactic material) was more effective (mode=median=”Yes”) than theoretical materials, solution examples with Math Cad and theoretical tests (mode=median=”Partly”) in students’ opinion. (Figure 4).

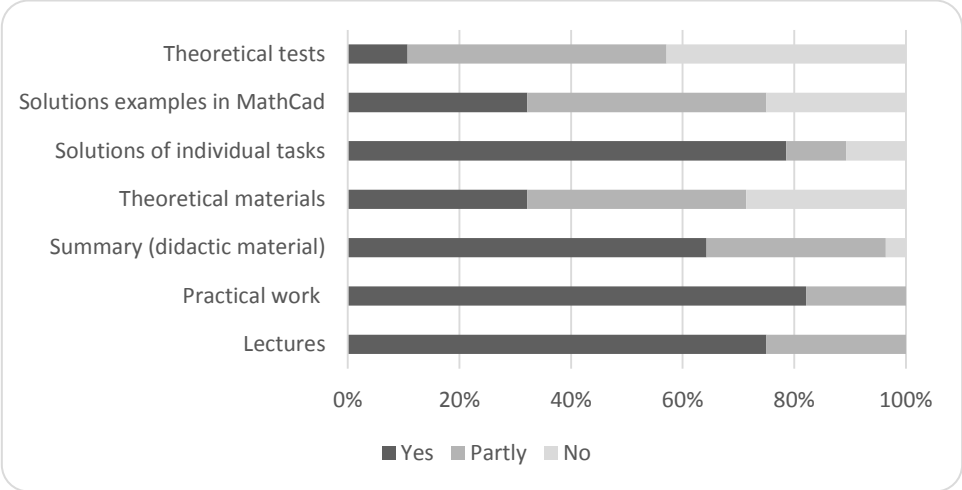

Figure 4. The students’ opinion regarding factors helping to acquire mathematics study course.

The students’ needs of the mathematics revision course is significantly correlated (Kendall's $\tau = 0.52$; $p<0.001$) with the importance of theoretical didactic materials for higher mathematics studies and vice versa. Didactic course materials were more necessary for students that chose the remedial course. The summary of the mathematical topics and “Mate-1” summary (didactic material) have the same importance for students (Kendall's $\tau = 0.54$; $p<0.01$). The more successful students were during the “Mate=1” course, the less important they considered tutorials (Kendall's $\tau = 0.55$; $p<0.01$) and other students’ support (Kendall's $\tau = 0.53$; $p<0.01$).

Despite all the offered opportunities, 23.4% students failed in mathematics, 7.4% of them due to the lack of the background knowledge. Other 15% of students had sufficient mathematical knowledge, but they received unsatisfactory grade in the mathematics study course because the students did not comply with any of the requirements.

The analysis of the achievement of successful students (n=67) in mastering "Mate-1" course on the basis of the school training was carried out. The grade of the LUA study course "Mate-1" significantly correlated with the grade of the secondary school. Hence the success of the development of mathematics depends essentially on the knowledge and skills acquired in the secondary school (Table1).

Table1.

The results of correlation analysis: Spearman's coefficients (r_s); Pearson's coefficients (r_p)

n = 67; p = 0.01	**Grade in mathematics in secondary school (score)**	**Grade in centralized secondary school exam in mathematics (%)**	**Test on elementary mathematical concepts (%)**
Grade in the centralized secondary school exam in mathematics (%)	$r_s = 0.62$		
LUA test on elementary mathematical concepts (%)	$r_s = 0.65$	$r_p = 0.82$	
Grade in the LUA study course Mate-1 (score)	$r_s = 0.63$	$r_s = 0.68$	$r_s = 0.74$

The results of the LUA test of unsuccessful students (n=7) and students who left their studies (n=15) show a significant positive correlation with the achievement of the centralized secondary school exam, accordingly r_p=0.73 (p=0.03) and r_p=0.52 (p=0.03). The assessment of mathematical knowledge at the university does not correlate with the school assessment knowledge and the results of the LUA test of these students. It means that there are other reasons for the failure.

Conclusions

- The problem of the growing number of dropout students is topical for all universities. It is necessary to identify the reasons for the tendency, although reasons among universities may vary. But one of the main reasons, especially in engineering specialties, is insufficient mathematical competence.
- The success in the study process of mathematics depends essentially on the knowledge and skills received in the secondary school. There is a positive significant correlation between the results of the LUA test on elementary mathematical concepts, the grade in the centralized secondary school exam in mathematics and the grade in mathematics in secondary school.
- To improve the insufficient mathematical knowledge, remedial courses in mathematics were offered to students, the summary of the necessary mathematical topics was designed, the opportunity to attend tutorials was offered. Students also used the support of better students and private tutoring. Unfortunately, the students' interest in remedial courses was very low (mode =median="No"). According to the students' opinion, the summary of the mathematical knowledge was the most useful method for improving their knowledge of mathematics (mode =median=" Yes"). Tutorials and other students' support were important for acquiring a higher level (mode = median =" Yes"). Some of the students used private tutoring options (mode = median = " No"). Apparently, the students looked for the easiest and quickest ways to improve their mathematical knowledge.
- Much attention was paid to the improvement of the study process to enhance successful acquisition of higher mathematics. The analysis of students' opinion shows that practical exercises and solution for individual tasks as well as lectures were useful for mastering higher mathematics.
- Assessment of knowledge of mathematics at the university does not correlate with the school assessment knowledge and the results of the LUA tests for unsuccessful students. For 64% of the students it was not related to the lack of background knowledge in mathematics. It is possible to conclude that the main cause of the failure in the study course of mathematics,

however, was students' attitude toward learning, the failure to observe deadlines as well as the inability or unwillingness to learn. Those who wanted to learn and use the support passed mathematics successfully.

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