Causes of Failures in Mathematics by Engineering Students at Latvia University of Agriculture

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Abstract: The quality of teaching and learning mathematics has been one of the major challenges and concern of the educators especially for students of engineering. Mathematics comprises a wide variety of skills and concepts. One of the main roles of mathematics is the development of the ability to solve problems. Mathematics is often considered as a subject that students find hard to understand, therefore many universities are faced with the problem that students drop out due to mathematics. The aim of the research is to study causes for failure in Mathematics among engineering students. The study is based on the analysis of mathematics test results as well as the survey data analysis. The survey collected data and opinions regarding: 1) the curriculum, 2) the teaching process, 3) the learners: their low basic knowledge, difficulties to understanding, learning habits, attitudes toward learning process, home background, and the learner's emotional reactions and personality. The analysis of the survey results showed that the core problem at the Latvia University of Agriculture is not only insufficient students' background knowledge in mathematics, but also their attitude towards learning, psychological reaction against the first failure and laziness to make efforts to do additional tasks or attend tutorials.

Keywords: competences, causes of failures, mathematics, student related factors, university education.

Introduction

Engineering education should focus not only on the development of professional competences – professional knowledge, professional skills and reflection but also on the development of cognitive competence, ability to solve problems as well as social competences such as self-competence, co-operation and communication. The quality of the engineering education depends on the quality of individual study subjects. Mathematics studies have an impact on the development of the necessary outcomes for engineers' both directly and indirectly (Zeidmane, 2012). Everyone is aware of the direct impact of mathematics, which serves as a tool for solving and calculating various problems. However, much greater is indirect impact of mathematics providing such learning outcomes as the skills to formulate, solve engineering problems, use language of symbols, make long chains of logical conclusions.

In the 17th SEFI seminar "Mathematical Education of Engineers" which held in 2014, 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. The quality of teaching and learning mathematics has been one of the major challenges and concern of the educators. Mathematics is often considered as a subject that a student mostly finds hard to understand. (Prakash, Jerlin, 2014). Mathematics education should enable engineering students to communicate their ideas in an unambiguous and understandable way and should equip themselves with the analytical skills as practicing engineers. Mathematical courses have the highest dropout rate throughout the world. For example, in Germany, about 20 % of students who begin a mathematics programmes will fail to complete it, however, for students of mathematics-related fields, that number jumps to more than 30 % (Fox, 2010). A similar situation is in America, Europe, Africa, Asia. The teaching staff of many universities carry out the research to find out the reasons for a large number of students who have not passed mathematics, as well as look for ways to remedy the situation. Similarly, at the Latvia University of Agriculture (LLU) more than 25 % of the engineering specialities' students drop out just after the first year in which mathematics is one of the basic subjects.

The aim of the research is to study causes of failure in mathematics among engineering students at the Latvia University of Agriculture. The study is based on the analysis of mathematics test results as well as the survey data analysis. The survey collected data and opinions regarding: 1) the curriculum, 2) the teaching process, 3) the learners: their low basic knowledge, difficulties to understanding, learning habits, attitudes toward learning process, home background.

Methodology

Achievement in mathematics depends on several factors. One of the problems researchers mention is related to the learning process. The Swedish professor J. Lithner (Lithner, 2011) underlines two reasons for mathematics learning difficulties: 1) content understanding difficulties, 2) difficulties with mathematical processes.

The main problems of misunderstanding in mathematics content are: 1) inability to use mathematics as a language of symbols which combines a continuous unity of the verbal expression and 2) the sub-language of special symbols that are used according to the rules (Zeidmane, Sergejeva, 2013). Mathematics contains huge didactic units of learning material; in addition, the teacher cannot avoid reviewing complex definitions and long evidences in the process of teaching mathematics.

Another important point to mention is the fact that mathematics is characterized by long chains of logic conclusions which relate to difficulties in learning process. Many students are not ready neither physically nor mentally for the hard work to acquire long information units. Students have difficulties in understanding proof statements, making the transition from informal to formal reasoning and constructing proofs. Students should acquire creative and imitative reasoning.

On the other hand, "learning difficulties" is a relative notion. Everyone has difficulties, even the best. As Albert Einstein said, "do not worry about your difficulties in mathematics; I can assure you that mine are still greater".

The lack of mathematical competencies (Niss, 2002) is also an important reason for the difficulties to study mathematics at universities. Prior to the studies at the university, students learn mathematics for 12 years and during this time, students should acquire basic mathematical competencies which, of course, will be further improved by the university. The professors of Institute of Mathematical Sciences have identified eight key mathematics competences (Laursen, 2003): mathematical thinking, problem handling, modelling, reasoning competences, representation, symbol and formalism, communication and aids and tools.

Another research emphasizes six key mathematical competencies (Turner, 2011):

- communication,
- mathematising,
- representation,
- reasoning and argument,
- strategic thinking and using symbolic,
- formal and technical language and operations.

The cause of the large number of dropout students in mathematics is to be found not only in the acquisition of mathematics. There are other factors that contribute to students' poor performance in mathematics at Kenya (Mbugua, Kibet, 2012):

- student factors: entry behavior, motivation and attitude;
- socioeconomic factors: education of parents and their economic status;
- school-based factor: availability and usage of teaching/learning facilities, school type and teacher characteristics.

The group of professors from the United States (Cherif, Adams, 2014) did the research about the causes of student failure in universities, analyzing the problem and finding solutions that could productively lead to helping teaching staff teach and students learn and succeed. The research identified three main root-cause ***factors*** for students' failing: 1) student-related factors; 2) life and socioeconomic issues, 3) failures of the educational system (Figure 1).

The significant number of incoming students *is not ready for university-level work.* They have poor levels of or a complete lack of academic preparedness for university courses, the lack of learning and study skills, and/or lack of organizational skills (including time management and setting priorities).

Both the *lack of effort* and *poor or non-existent work ethics* as subcategories are not less important categories. Relatively often students do not complete assignments and consider that homework is unimportant. Sometimes students devote insufficient attention during class. Similarly, Professor

M.Ibrahim (Ibrahim, 2015) from Nigeria in his research recognized that failure in mathematics was due to apathy or hatred for the subject, laziness or lazy attitude to studying the subject.

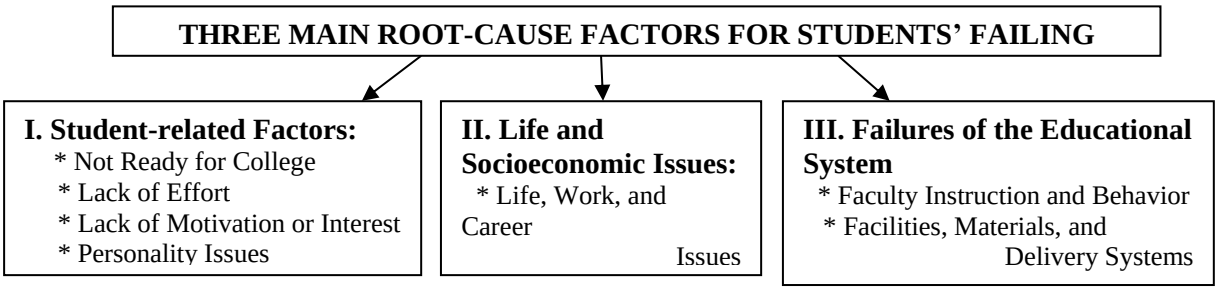

Figure 1. Identified Categories of Root-Cause Factors (adapted from Cherif, Adams, 2014).

*Lack of motivation or interest***,** persistence, and "not being active learners" are important categories too. Some students even do not care if they are students at a university or not.

The category of *personality issues* should not be overlooked comprising *the lack of social connection, lack of support system and network* and *poor self-esteem and self-confidence.*

Factors "*Life and Socioeconomic Issues***"** and **"***Failures of the Educational System***"** that affect students' academic failure in mathematics are important, too, but solution of these problems requires changes in the study programme and in all educational system, and it is not the responsibility of the authors.

As regards the Latvia University of Agriculture (LLU), one of the main causes of failure assessments in mathematics is related to the factor that students are *not ready for university*. A significant number of incoming students lack the background knowledge, mathematical competencies including scientific reasoning skills, learning and study skills, responsibility for the learning process, organizational skills (including time management and setting priorities).

Many studies, events and activities have been carried out by the Department of Mathematics of the Latvia University of Agriculture with the purpose of improving results of mathematics learning process. Nevertheless, the teaching staff often notes that students do not use these opportunities, therefore the aim of the study is to explore the student-related factor as the cause for students' failure.

In order to achieve the aim of the research, the survey was carried out. The survey questions were divided into the following four groups: 1) students' success measured by grades, 2) work invested in learning process, 3) attitude to the learning process, 4) competencies necessary for learning mathematics.

The following research methods were used to analyse the survey results: descriptive statistics and correlation analysis.

Results and discussion

In order to identify causes for failure in mathematics among students of engineering programmes, the research was carried out in the Department of Mathematics of the Latvia University of Agriculture. Over 100 students were surveyed within this study. The survey was conducted with the aim to find out students' opinion and self-assessment of their success, acquired competences in mathematics and the time evaluation that was consumed for studying mathematics. The results of students' questionnaires from the Faculty of Information Technology (FIT) and Faculty of Engineering (FE) were compared.

The results show that only 30 % of the first-year students from FE who finished a gymnasium and 23 % of students from FIT have received more than 70 % of the assessment score in the centralized exam. It is disturbing that 60 % of students from FE and 23 % of students from FIT have received less than 40 % score (Figure 2). The obtained results indicate to low basic knowledge in mathematics. It is not surprising that only 10 % of the students from FE and 31 % of the students from FIT have received more than 70 % of the assessment score on LLU 1st task test.

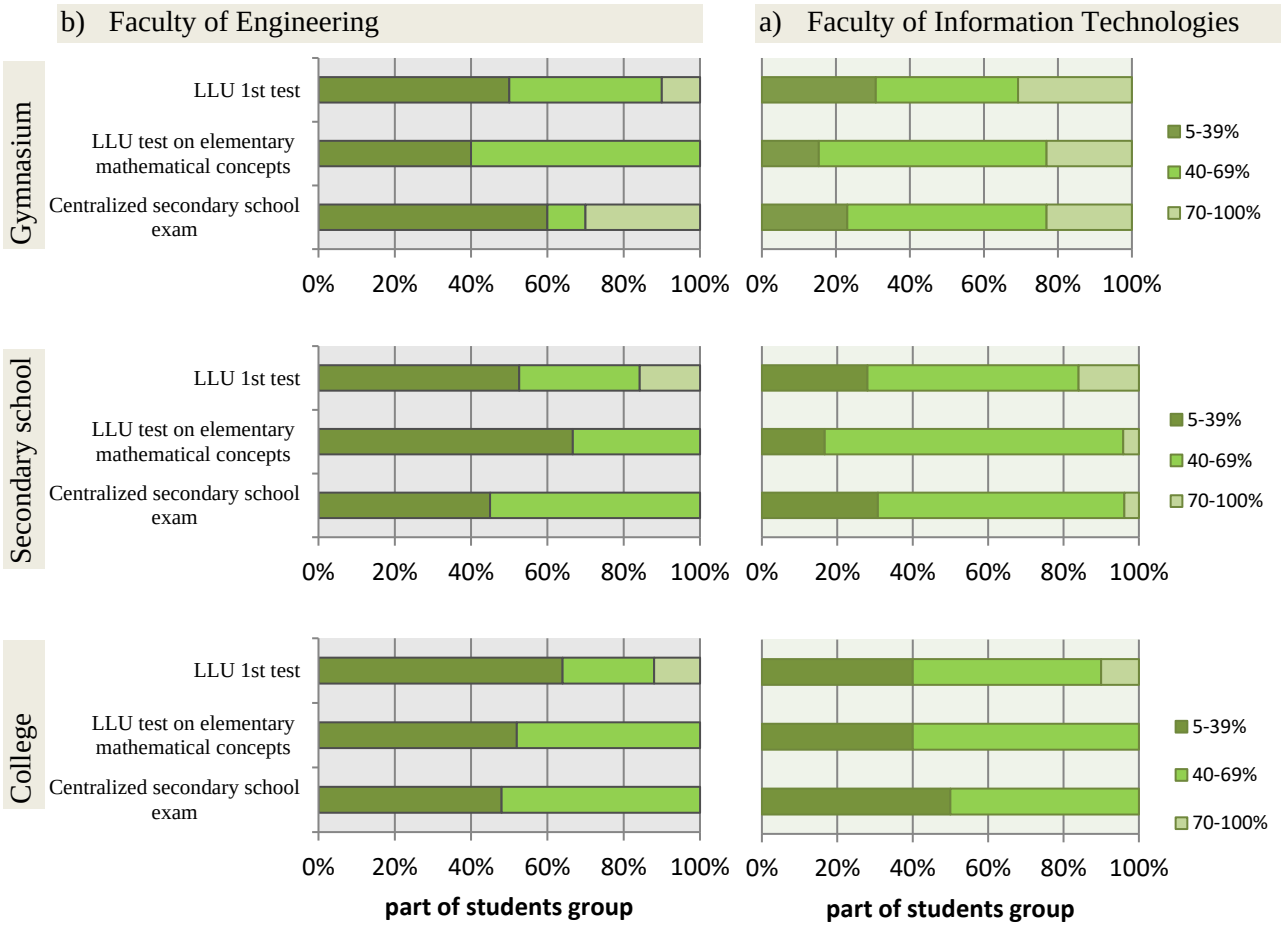

Figure 2. The results of students who graduated from Gymnasium, secondary school and college.

Results of the first year students who finished a secondary school are worse. In this group no students (total 20 students) from FE and only one student (total 26 students) from FIT have received more than 70 % of the assessment score in the centralized exam. Their results in LLU 1st task test also are lower. Results of the first year students who finished a college are similar to students who finished a secondary school. Almost 50 % of both faculties' students received less than 40 % of the assessment score in the centralized exam. Their results on LLU 1st task test also are weak. Only 12 % of students from FE and 10 % of the students from FIT have received more than 70 % of the assessment score in LLU 1st task test.

The results of the first year students show mostly average basic knowledge of mathematical concepts. The results of students from FIT are slightly better than FE students' results. More than 60 % of students received more than 40 % of the assessment score in LLU test on elementary mathematical knowledge. However, relatively better knowledge is shown by students who finished a gymnasium. FE students have showed the lack of knowledge. The results show that 40 % of students who finished a gymnasium, 60 % of students who finished a secondary school and 52 % of students who finished a college received less than 40 % of the assessment score in LLU test on elementary mathematical knowledge and none of them received more than 70 % of score. The correlation was analysed between the results of the LLU 1st task test and the grade in the centralized secondary school exam in mathematics. In case of FE students there was a positive medium correlation between the results of the LLU 1st test, the grade in centralized secondary school exam $r_S = 0.54$ ($p=0.01$) and the grade in LLU test on elementary mathematical concepts $r_S = 0.52$ ($p=0.01$). In case of students from FIT there was only a positive medium correlation between the results of the LLU 1st test and the grade in LLU test on elementary mathematical concepts $r_S = 0.36$ ($p=0.01$).

At the end of a secondary school students must have developed competencies such as the use of symbol language, mathematical representation, problem solving, opinion formation and others. The results of students' competencies are divided into two groups according to the faculty (Figure 3).

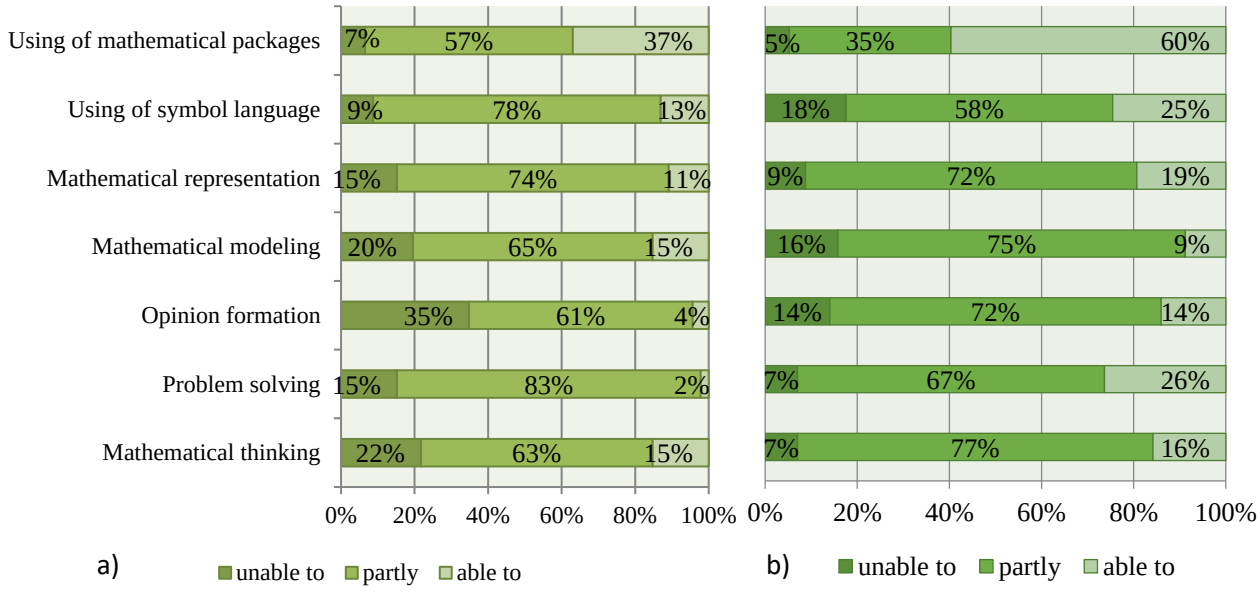

Figure 3. The results of students' competencies assessment:
a) students from the Faculty of Engineering;
b) students from the Faculty of Information Technology.

The results show that students from FIT evaluate their competences as relatively secondaryer developed than the FE students. The majority of respondents consider that competences are developed partly. As the results show, 78 % of students from FE and 58 % of students from FIT can partially use symbol language (mode = median = "partly"). At least 72 % of students from both faculties can partially create graphs and present results in mathematical manner (mode = median = "partly"). Not more than 16 % of both faculties' students have developed mathematical thinking. Only 2 % of students from FE and 26 % of students from FIT are able to solve mathematical problems (mode = median = "partly"). Likewise, the competence of opinion formation is evaluated. Only 37 % of students from FE (mode = median = "partly") and 60 % of students from FIT (mode = median = "able") are able to use mathematical packages.

The mathematical thinking competence of students from FIT (Spearman's r_S = 0.41; p=0.01) has medium correlation with a grade of the centralized secondary school exam. Other competences have low correlation with a grade of the centralized exam. The mathematical thinking competence of students from FE (Spearman's r_S = 0.3; p=0.05), problem solving (Spearman's r_S = 0.32; p=0.05), opinion formation (Spearman's r_S = 0.43; p=0.01) significantly correlated with a grade of the centralized secondary school exam.

Several opportunities are provided to students to improve their mathematical knowledge. As one of the possibilities, a remedial mathematics course was offered to students. Students with unsatisfactory test results, especially those with the test score less than 40 %, were supposed to attend it. Unfortunately, the students' interest in these courses was very low, only 20 % attended the course. The other option was the design of the summary of the necessary mathematical topics by the department staff. To support students, students were encouraged to use tutorials where revision of the secondary school mathematical topics was provided.

The ***attitude*** towards learning process is a much more important problem. It is not possible to expect good results in LLU task tests if students with low skills and basic knowledge in mathematics do not attend lectures and do not perform the homework in the allotted time. Moreover, students have an opportunity to attend consultations and to get the help in doing homework from the teaching staff. Step-by-step examples of practical mathematics problem solutions with MathCad in the e-environment are available for students as well.

The grade of LLU 1st task test of students from FE (Spearman's r_S = 0.52; Kendall's r_K = 0.48; p=0.01) has a medium correlation with the factor "timely done homework". But in case of students from FIT

there was a positive medium correlation between the results of the LLU 1st task test and "the timely done homework" (Spearman's $r_S = 0.32$; $p=0.05$).

The results of the survey show that students were keen to attend lectures (mode=median="Yes"): 91% of FE students and 93 % of students from FIT gave positive answers (Figure 4).

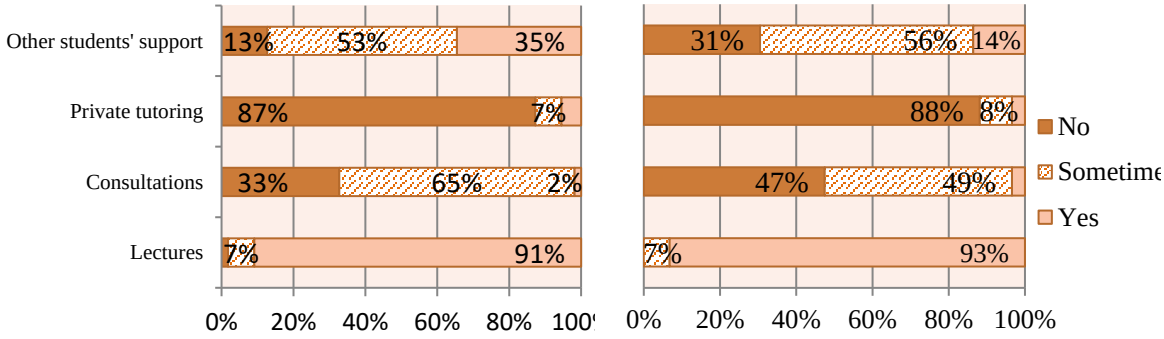

Figure 4. The students' opinion regarding factors helping to improve their mathematical knowledge:
a) students from the Faculty of Engineering
b) students from the Faculty of Information Technology.

However, students of both faculties rarely use other options that can help them to improve mathematical knowledge and achieve a higher level of mathematics. Unfortunately, 33 % of FE students and 47 % of students from FIT do not use teachers' consultations. It should be noted that more than 87 % of students of both faculties do not use private tutoring. It pleases that 35 % of FE students and 14 % of students from FIT ask for help to group mates regularly and more than 53 % of both faculties' students do it sometimes.

The analysis of the survey results related to students' contribution to their study process showed that almost every student listens during practical work and tries to understand the study material. However, there are students, e.g. 15 % of both faculties' students that sometimes do not try to follow lectures and understand the material (Figure 5). Taking into account the fact that homework should be completed until the task test, more than 48 % of students from FE and more than 34 % of students from FIT not always complete the homework in the available time.

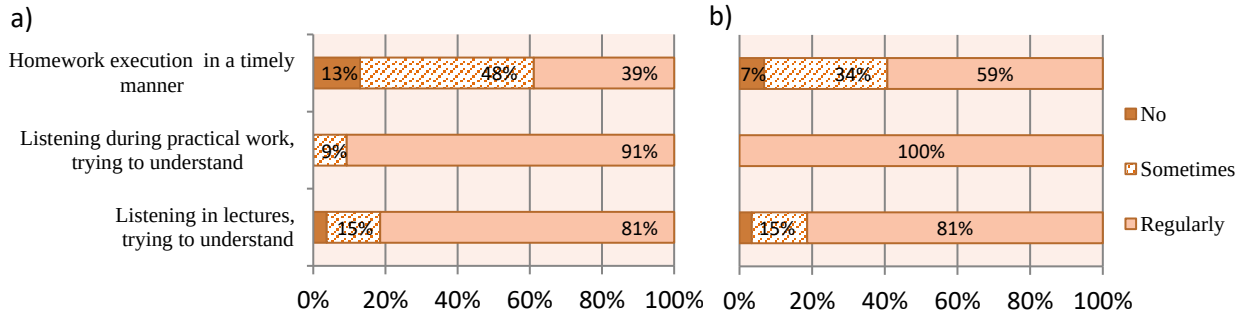

Figure 5. The students' opinion regarding factors helping to achieve higher level of mathematics:
a) students from the Faculty of Engineering;
b) students from the Faculty of Information Technology.

One of the key factors of success in the learning process is students' motivation and dedication. A large-scale problem is laziness and the so-called "student syndrome", i.e., tendency to postpone the work until the last moment. For this reason, one of the survey questions asked respondents to evaluate the time they spent for learning mathematics. The results are summarized in Figure 6.

In order to achieve better results in tests students should work independently, i.e., individually. According to the university programme, a student needs to spend at least 4 hours on individual work. The results show that the most part of students devotes no more than 4 hours to doing homework. A little more time is devoted by the students from Faculty of Information Technologies. It is not surprising that more than 50 % of students of both faculties spent less than 2 hours on preparation process for 1st task test.

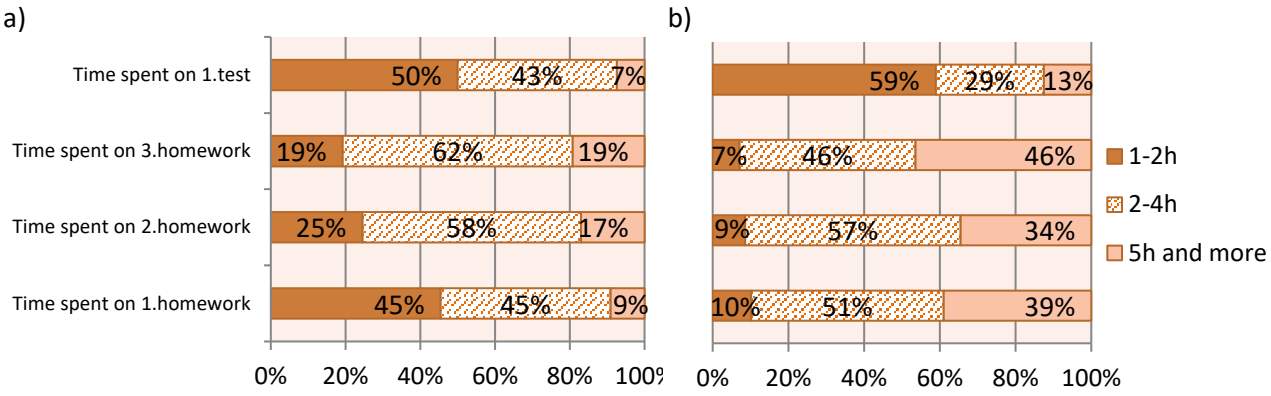

Figure 6. The students' opinion regarding factors helping to improve their mathematical knowledge and achieve higher level of mathematics: a) students from the Faculty of Engineering; b) students from the Faculty of Information Technology.

Conclusions

- The problem of the growing number of dropout students is typical for many universities. It is necessary to identify the reasons for this tendency. One of the main causes in LLU is a lack of background knowledge in mathematics which is evidenced by the students' results of the centralized secondary school exam which correlates with LLU test on elementary mathematical concepts.
- The second important cause is insufficiently developed mathematical competences which disturb successful acquisition of new material in mathematics.
- The problem which is much more important refers to students' attitude towards learning process. Many students do not to perform homework in the allotted time (61 % of FE and 41 % of FIT students), although they have an opportunity to attend consultations and get help of the teaching staff in homework. Only 2 % of FE and 4 % of FIT students attend consultations regularly.
- Another important cause is a lack of effort, as it is evidenced by the fact that more than 50 % of students of both faculties spend less than 2 hours on preparation process for successful completion of 1st task test.
- Thus it can be concluded that the most part of the first year students are **not ready for the studies at the university**. A significant number of incoming students has the lack of background knowledge, the lack of mathematical competencies including scientific reasoning skills, the lack of learning and study skills, responsibility of the learning process, organizational skills (including time management and setting priorities).

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