GOOD KNOWLEDGE OF BASIC MATHEMATICS – A SUCCESSFUL PREREQUISITE TO STUDY IN RIGA TECHNICAL UNIVERSITY

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Abstract. The issue viewed in this paper, which affects a multitude of technical universities: an insufficient level of basic mathematical knowledge among students. The 2016/17 centralized State examination, as well as, basic mathematical knowledge examinations done by Riga Technical University have been analyzed. The results show that a large part of students do not have the required level of knowledge in basic mathematics to successfully study calculus. Measures that RTU is using to avert these issues are mentioned.

Keywords: higher education, attitude, mathematics, teaching approach, educational process

Mathematics Subject Classification: 97D50, 97C70, 97D60

1 Introduction

Engineers are highly valued and demanded in the labor market, which means the quality of education of young engineers has a crucial role in the future of the country. Evidence shows that it is much easier to study if the students already have a high level of knowledge of exact sciences. Sadly, evaluating the knowledge of basic mathematics among students accepted into the university, it shows that many of them are not knowledgeable enough to successfully study calculus. For years now, we have been looking for ways to help these students stay in university and successfully finish their studies.

Working as lecturers in four faculties of Riga Technical University (RTU): Faculty of Computer Science and Information Technology, Faculty of Power and Electrical Engineering, Faculty of Civil Engineering, Faculty of Mechanical Engineering, Transport and Aeronautics, the application of mathematical knowledge among specialists is very important in our area of work. We look for answers to the questions: what it is, what should be taught, and how it should be done in order for this obtained knowledge to be useful in professional work.

2   Centralized State examination in mathematics

The obligatory state centralized examination (CE) in mathematics was introduced in the academic year of 2008/2009. This exam is also done by vocational school pupils, and it is made in such a way that many different schools can use it.

The exam consists of three parts. The first part, "Knowledge and basic skills," contains 15 questions with multiple choice answers and 10 questions with short answers. In total, there are 25 questions, each worth one point. The second part, "Application of knowledge in standard situations," contains 10 expanded problems (worth 40 points in total). The third part "Application of knowledge in non-standard situations" consists of three expanded problems (worth 15 points in total).

How are exams graded?

For example: Mathematics – overall score 85% (Knowledge and basic skills 96%, application of knowledge in standard situations 80%, application of knowledge in non-standard situations 80%). 24 out of 25 possible points have been earned in the 1st part (knowledge and basic skills), which is 96%. 32 out of 40 points have been earned in the 2nd part (application of knowledge in standard situations), which is 80%. 12 out of 15 points have been earned in the 3rd part (application of knowledge in non-standard situations), which is 80%. And then the overall score is calculated (24+32+12): (maximum of 80 possible points), or 85%.

Rezultātu sadalījums eksāmenā : matemātika

	Zem 5%	5% – 10%	11%-20%	21%-30%	31%-40%	41%-50%	51%-60%	61%-70%	71% – 80%	81% – 90%	91% – 100%
2016	199	1394	2751	2319	1992	1711	1311	987	731	476	314
2017	219	1337	3001	2274	1691	1365	1077	848	688	513	322

Fig. 1. The distribution of scores in the state centralized examination in mathematics in the academic year of 2016/17.

A little over 13 300 students did these centralized state exams in the academic year of 2016/17. According to the information given by National Centre of Education of the Republic of Latvia, the average overall score in these exams for students in the 12th grade was 34.9%, which is 1.3% less than the last academic year. The distribution of scores in the centralized state examination in mathematics in the academic year of 2016/17 is shown in Figure 1.
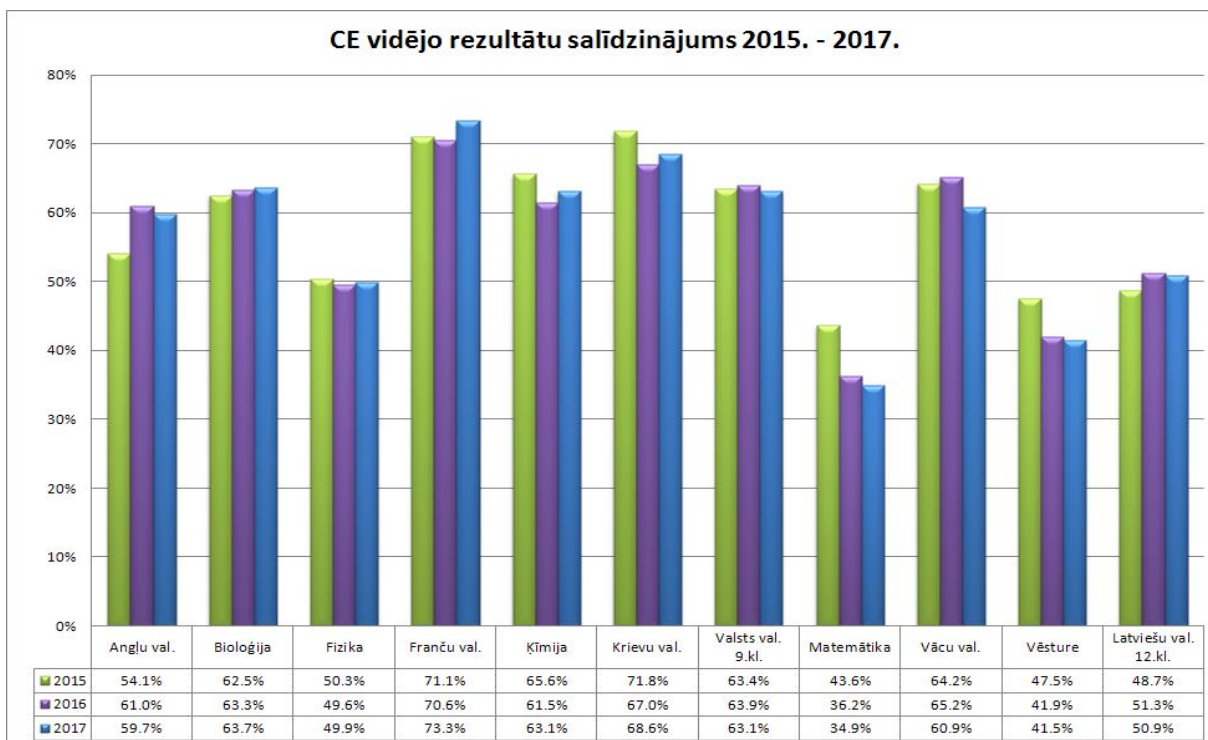
	Anglu val.	Bioloģija	Fizika	Franču val.	Ķīmija	Krievu val.	Valsts val. 9.kl.	Matemātika	Vācu val.	Vēsture	Latviešu val. 12.kl.
2015	54.1%	62.5%	50.3%	71.1%	65.6%	71.8%	63.4%	43.6%	64.2%	47.5%	48.7%
2016	61.0%	63.3%	49.6%	70.6%	61.5%	67.0%	63.9%	36.2%	65.2%	41.9%	51.3%
2017	59.7%	63.7%	49.9%	73.3%	63.1%	68.6%	63.1%	34.9%	60.9%	41.5%	50.9%

Fig. 2. A comparison of state centralized examination scores in the years 2015-2017.

In the second graph, the comparison of centralized state examinations in different subjects is shown in the last three years. The 1st column shows the results in English, 2nd – biology, 3rd – physics, 4th – French, 5th – chemistry, 6th – Russian, 7th – Latvian (9th grade), 8th – mathematics, 9th – German, 10th – history, 11th – Latvian (12th grade).

It is clearly visible that the worst scores are in the mathematics examination, and are only getting worse each year. Students' results over many years show that simple mathematical skills (dealing with algorithms), which every teacher tries to teach and develop, are still not at a good enough level. The same can be said about students' results in problems where conceptional knowledge is required. The inability to deal with logical tasks among students is frightening. However, it isn't anything new, as previous analysis show that students have no issues learning given materials, but encounter problems when asked to use them. Students' failure to successfully complete logical tasks shows that a change in **methodology of teaching** is necessary.

3   Basic mathematical examination done by RTU

If a student has had difficulties with basic mathematics in high school or exams, they are given the chance to attend additional lessons in RTU. The offer of these additional lessons for students with weaker understanding of basic mathematics has been in use for over five years now. Though it was offered as more of an offer for those who wished, starting with the 2016/17 academic year, it's been marked as obligatory for all students who fail a specific test at the beginning of the year.

As experience shows, a lot of the students accepted into the university do not have required level of knowledge in basic mathematics to successfully finish their studies in calculus and other technical subjects. During the first mathematics lesson of studies, students are given tests to determine how

good their understanding of basic mathematics is. This test consists of five simple problems: operations with fractions, the expression of a variable from a linear relationship, construction of a line and a parabola in a plane, basic properties of powers and basic properties of logarithms. Each problem is worth 2 points. The test is successfully completed if student gets at least 4 points. In the academic year of 2017/18 1553 first year students did this test. Sadly, almost half of them (38%) couldn't correctly complete even two of these five problems.
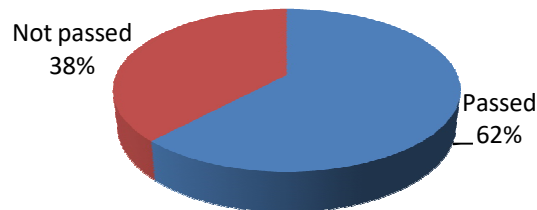
Fig. 3. A pie chart showing the percentage of students that could and could not successfully complete the test with a passing mark.

Only 6% of students solved all the problems correctly and received the maximums 10 points, however 7% got 0 points, as in, they couldn't even begin to solve these problems correctly. The most common mark is 2 points, which means that the student completed one problem successfully, or did two problems halfway. The Figure 4 shows the percentages of marks.
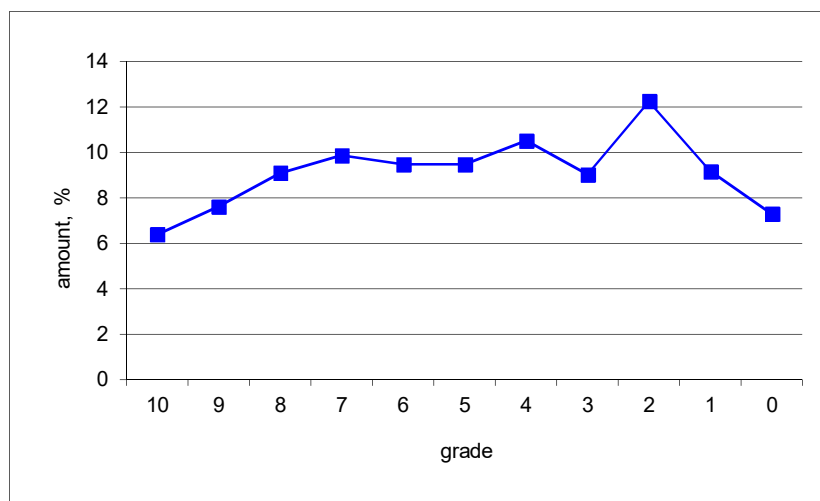

Fig. 4. Percentages of marks among students.

Comparing these results to the last five years (which are shown in Figure 5), we can see that they change every year, getting better one year, but worsening the next one.
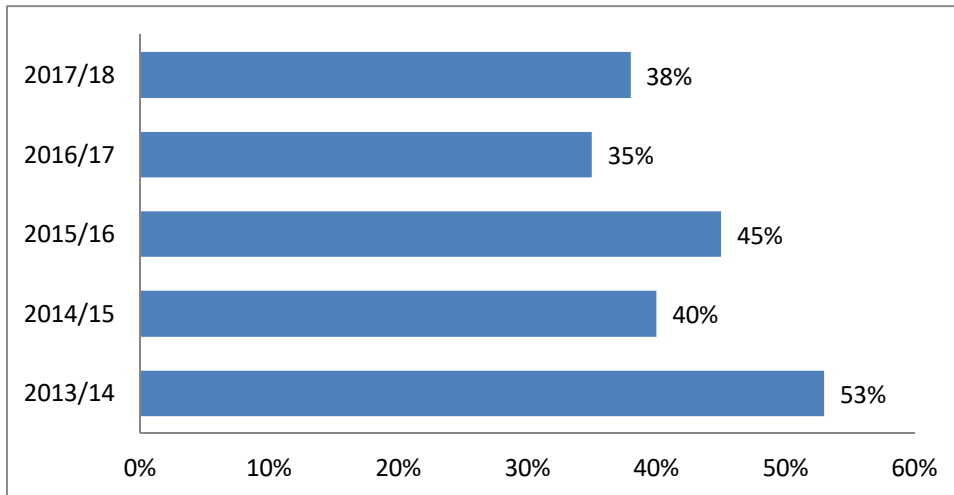
Fig. 5. A comparison of unsuccessful students in the last 5 years.

We made a comparison between the CE results that students receive in school and the tests students did in one of RTU's faculties (Faculty of Computer Science and Information Technology). We chose the faculty where results were the best. The comparison is seen in Figure 6. The horizontal axis shows CE results, but the vertical one shows the RTU test results. Considering that the tests done in RTU are much easier than the centralized state examination, the results should be better. Drawing a diagonal over the graph, we can see that there are more points under it than above it, which means that most students had worse marks than the CE results.
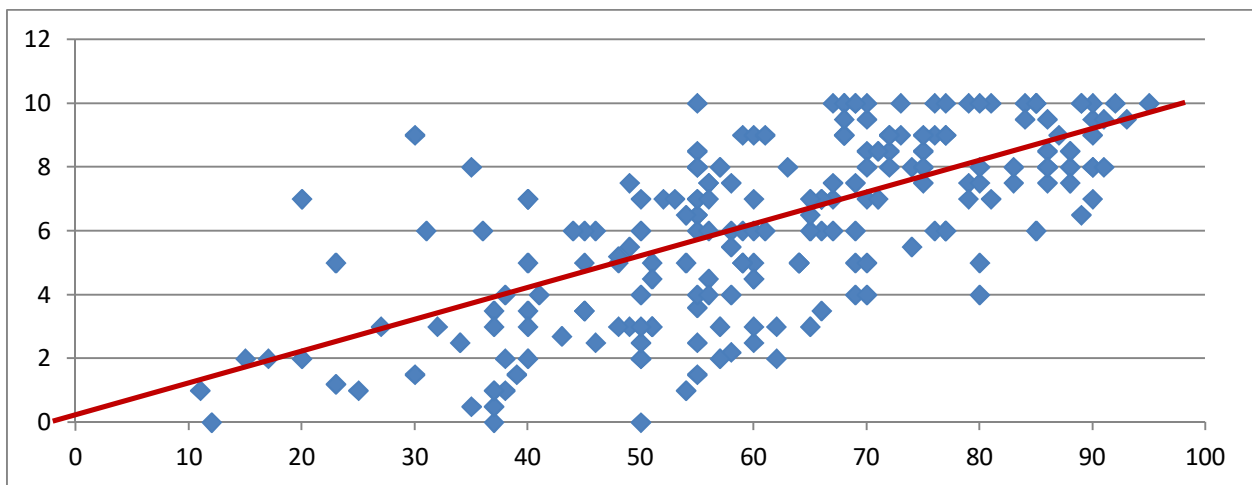

Fig. 6. A comparison between students' CE results and the basic mathematics test results.

Roughly comparing 100% on the CE to 10 points in the test done by RTU, 90% - 9 points etc., we can see that the marks of 47% of students get worse. From this we can conclude that the knowledge of students is unstable, and, instead of preparing for studies, students instead manage to forget what they've learned. This leads to the aforementioned conclusion, that it is necessary to change the methodology of teaching.
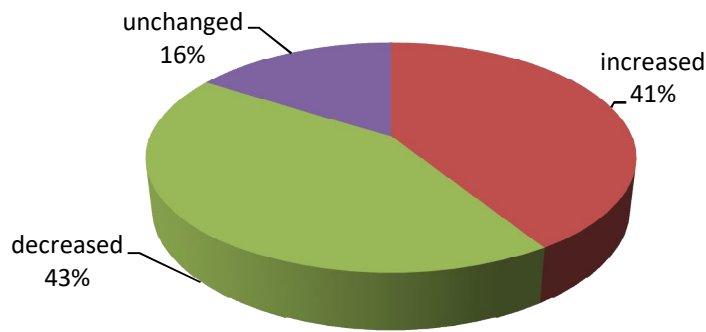
Fig. 7. A pie chart showing the percentages of students whose RTU test results, compared to CE results increased or decreased.

4 Search for the solution

The lecturers of RTU Department of Engineering Mathematics have taken a series of steps to help those students that do not have enough knowledge of basic mathematics.

1) Two lessons a week are dedicated to studying basic mathematics for first year students. It is obligatory for those who failed the basic mathematics test at the beginning of the year, but optional for all other students.
2) A video lecture course that is freely available for all on the YOUTUBE website has been created.
3) A support course covering basic mathematics has been created on the website mooc.rtu.lv.
4) There are materials available on the RTU website ORTUS for students to use.
5) A book "Fundamentals of Basic Mathematics" (in Latvian), which teaches the necessary knowledge of basic mathematics to successfully finish higher education, has been issued.

However, the aforementioned steps are only an attempt to fix consequences. The goal should be to eliminate the causes by changing the methodology of teaching. Beginning with the next academic year, a gradual transition into a thorough learning content will take place in Latvia. In accordance to it, the teaching approach will be changed to ensure that pupils develop the skills and understanding of science necessary in modern times. We can only hope that the result of this change will be what we hope for and the next students will not only have the basic skills required, but will also know how to adapt to new circumstances, develop the better parts of their personalities and create a specific system of values.

5 Conclusions

1) The state centralized examination should be divided into two levels. One would be for those who wish to further study in university, the second – for everyone else. The exam should be made much more serious for the first group. However, if a person decides to study in university after graduation, it should be possible to take the exam at a later time.
2) Almost half of the students accepted into RTU do not have the necessary level of knowledge in basic mathematics to successfully finish their studies. Not to be forced to leave university during the first session, they should be given extra help with learning basic mathematics.

3) Concerning suggestions in bettering the mathematics programs, it is recommended to integrate mathematics applications (MathCad and MatLab) into the study process and teach students the practical uses of mathematics.

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