

## Mathematics Admission Test Remarks

\*Erge Ideon, Eve Aruvee

Estonian University of Life Sciences, Institute of Technology,

Fr. R. Kreutzwaldi street 56/1, Tartu 51014, Estonia

**Abstract.** Since 2014, there have been admission tests in mathematics for applicants to the Estonian University of Life Sciences for Geodesy, Land Management and Real Estate Planning; Civil Engineering; Hydraulic Engineering and Water Pollution Control; Engineering and Technetronics curricula. According to admission criteria, the test must be taken by students who have not passed the specific mathematics course state exam or when the score was less than 20 points. The admission test may also be taken by those who wish to improve their state exam score. In 2016, there were 126 such applicants of whom 63 took the test. In 2015, the numbers were 129 and 89 and in 2014 150 and 47 accordingly. The test was scored on scale of 100. The arithmetic average of the score was 30.6 points in 2016, 29.03 in 2015 and 18.84 in 2014. The test was considered to be passed with 1 point in 2014 and 20 points in 2015 and 2016. We analyzed test results and gave examples of problems which were solved exceptionally well or not at all.

Keywords: teaching mathematics; admission test; mathematics education; basic competence in mathematics.

### Introduction

#### *Mathematics education in Estonia*

Mathematics education has been changing and developing in Estonia for the last 25 years of independence. Since 1989 a number of drafts for school mathematics curricula have been drawn up in Estonia. In upper secondary schools, the subjects are divided into courses. Regarding the obligatory mathematics course, there is a possibility of choosing between narrow and extended mathematics course. This means that at the same time, along with standard mathematics course consisting of 8 courses (each course is 35 academic hours), a 14-course extended course is taught (Lepmann L., Lepmann T., & Afanasjev, 2009). According to the national curricula, the completion of the courses in extensive mathematics enables students to continue their studies in areas where mathematics is essential and is taught as an independent subject. Such concepts and methods are disserted that is needed to understand the essence of mathematics as a science. On the other hand, the completion of the courses in standard mathematics enables students to continue their studies in areas where mathematics is not as important and is not taught as an independent subject. Unlike extended

mathematics course the standard version has the main purpose not to study the science itself but to look at the applications of mathematics in order to describe the world around us scientifically and to ensure coping with life generally (National curriculum for upper secondary schools. Appendix 3, 2011).

#### *State examination system in Estonia*

The system of state examinations (riigieksamid) for general secondary school graduation in Estonia was introduced in 1997. Since August 2012, the state examinations have been administered by the Foundation Innove (Sihtasutus Innove). More information about mathematics state examination could be found from (Kaljas, 2006). Since 2014, graduation from upper secondary school requires the student to complete a curriculum consisting of at least 96 individual courses passed at a satisfactory level as a minimum; passing the state exams consisting of the Estonian language or Estonian as a second language, mathematics and a foreign language (English, French, Russian or German); passing the upper secondary school exam which is selected, prepared and organized by the school as well as completing a student research paper or practical work during the

\* Corresponding Author's email:

[Erge.Ideon@emu.ee](mailto:Erge.Ideon@emu.ee)

entire study period. The instruction, compilation and assessment of student research paper or practical work are organized by the school. Since there are two different mathematics courses available, a student may also choose between a standard and an extensive version of the state examination in mathematics. State examinations are graded on a 100-point scale. The student who gets at least one point out of the hundred available at the examination, can graduate from the upper secondary school. As the state exams give good bases for comparison, they first and foremost provide for a full overview of the state of education in the country. State examinations also serve as entrance examinations for higher education institutions although tests, interviews etc., may be required in addition. The function of entrance into universities is secondary, here (National curriculum for upper secondary schools, 2011).

#### *Changes in admission criteria in Estonian University of Life Sciences*

University degree programs have very different mathematics requirements. Due to the changes in the state examination system in Estonia and possibility of studying either standard or extended mathematics, while entering university, students have very diverse knowledge and skills in mathematics. Our university has given a change for upper secondary school graduates to apply to specialties where mathematics is essential even if the amount of mathematics they have studied before is not enough. There have been admission tests in mathematics since 2014 for applicants to the Estonian University of Life Sciences for Geodesy, Land Management and Real Estate Planning; Civil Engineering; Hydraulic Engineering and Water Pollution Control; Engineering and Technetronic curricula e.g. for specialties where mathematics is taught as an independent subject. These new rules mean that since the autumn of 2014 the selection for places for all applicants takes place either through grades from upper secondary school and from national exams or through results on the admission test. Many other universities in Estonia have entrance exams as well e.g. Tallinn University of Technology has mathematics admission test with similar admission criteria as in Estonian University of Life Sciences (Tallinn University of Technology, 2016). Higher education admissions processes also vary internationally. Most countries have additional requirements for university entrance, such as admissions tests or interviews in addition to the certificate of secondary school completion or its equivalent. An article by Rebecca Zwick (Zwick, 2010) provides a brief historical perspective and then describes several aspects of higher education

admissions testing in the USA. In the present article, we analyze the results of admission tests in Estonian University of Life Sciences between 2014 and 2016.

## **Material and Methods**

### *Admission test criteria*

According to admission criteria in Estonian University of Life Sciences, the entrance test must be taken by students who have not passed the specific mathematics course state exam or when the score was less than 20 points. The admission test may also be taken by those who wish to improve their score of the state exam. Each year there are up to 20 students who use this opportunity.

### *Admission test structure*

The test was scored on scale of 100. The test was considered to be passed with 1 point in 2014, and there were 10 problems to solve in the time frame of 180 minutes. In 2015 and 2016, 20 points were needed to enter the university. Since 2015, the admission test has had 2 parts – a test part with 20 multiple choice questions and 8 problems to solve. Each multiple choice question had 1 correct answer which gave 1 point. There were questions about percentages, solving simple equations, simplifying expressions, choosing equivalent (simpler) expressions for the given expressions, fractions, fractional expressions, general arithmetic, calculating areas and volumes etc. The basic concepts and problems were dealt, so for students who had well mastered their school material, the test part should have been relatively easy. The applicants were advised to use an extra page to do the calculations during the test. Each problem in the second part of the admission test was graded out of 10 points. The time limit for test was 45 minutes and for problems 135 minutes. The use of calculator was allowed, but all other devices (e.g. mobile phones, tablets etc.) were prohibited. Also, formula sheets were not allowed. The admission test was based on the following topics: fractions; algebraic expressions; equation of a line; sequences; functions; equations and inequalities, equation systems; percentage, limit of a function; derivative of a function; investigation of a function; integrals; stereometry. For preparation, the applicants were advised to solve problems from previous years state exams (especially from extensive version of paper) because the entrance exam has similar problems to solve.

## **Results**

### *Statistics*

In 2016, there were 126 applicants who needed to take the test to apply to university of whom 63 came to

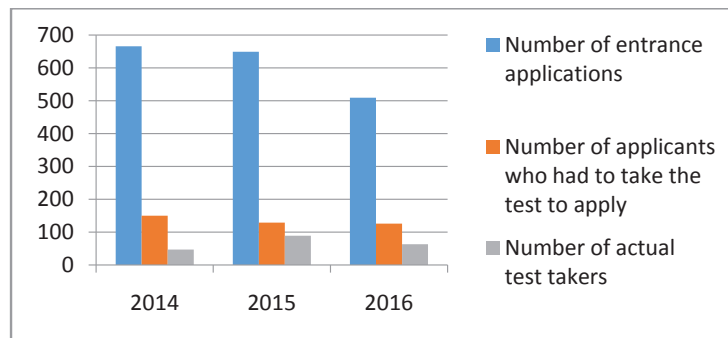


Figure 1. Number of applicants.

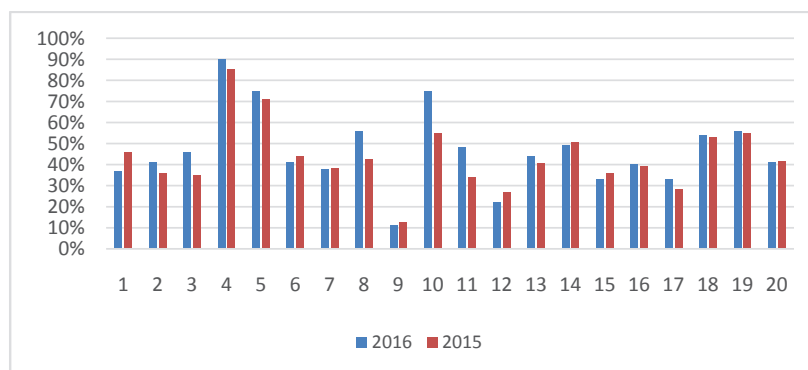


Figure 2. Multiple choice test results by task.

take the test. The total number of candidates was 509. In 2015, the numbers were 129 and 89 (of total 649) and in 2014 150 and 47 (of 666) accordingly (Figure 1). We can say that each year approximately 20-25% of applicants needed to take the admission test.

The arithmetic average of the score was 30.6 points in 2016, 29.03 in 2015 and 18.84 in 2014. For comparison, in 2015 the mathematics state exam average was 50.8 (extensive version) and 37 (standard version). It seems that the change in organization, i.e. adding the multiple choice test part with some easier questions, has raised the average. Since the applicants who did the admission test, had taken the state exam some years ago or had chosen

the narrow mathematics exam (and thus, presumably passed the standard course in upper secondary school), the average test score is more comparable to standard mathematics state exam score. The best test score was 79 (in 2015). In 2014, the best score achieved was 69 and in 2016 it was 71. The lowest score was 3 points each year.

In 2015, there were 23 student candidates (25.8% of students who took the test) who got less than 20 points in admission test and therefore did not qualify for studies at the university. In 2016, the number of applicants was 16 (25.4%). As in 2014 only 1 point was needed to pass, there were no applicants who failed the exam.

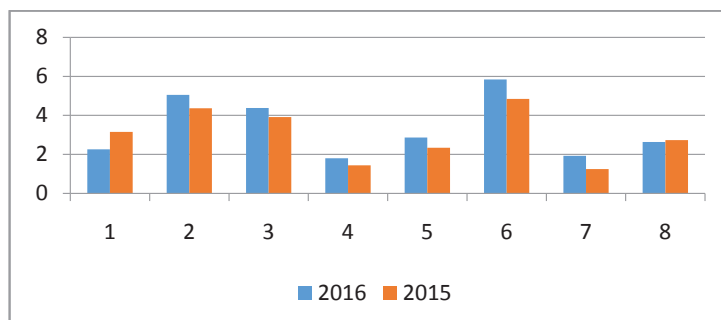


Figure 3. Results by task in the second part of test.

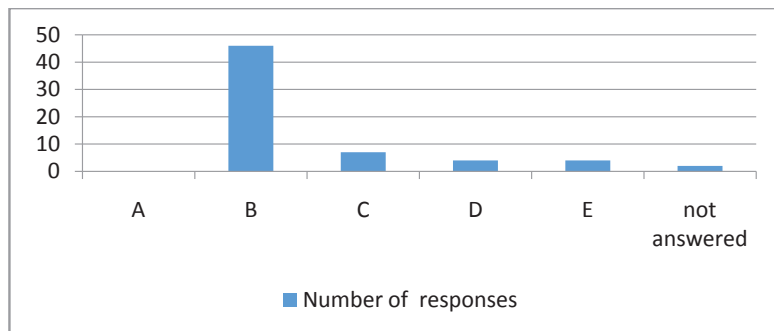


Figure 4. Answers of the most difficult question.

As in 2015 and 2016 the admission test had the same structure and also the same questions and problems were given, it is possible to compare the results. The results were reasonably consistent. The average in multiple choice test in 2016 was 9.3 points (out of 20) and in the second part 21.3 (out of 80). In 2015, the numbers were 8.7 and 20.3. In Figure 2 and Figure 3, we see that there are no substantial differences between those years' results as we compare the average points the applicants got for each question and task.

#### Least and most difficult items

Next, we gave the items that were least difficult and those that were most difficult to applicants (based on the percent of correct answers). Most incorrect answers (in 2016 84%) got the question:

*How much acid do you need to add to 4 litres of water to get a 24% solution?*

- A. 0.26
- B. 0.96
- C. 1.26
- D. 3.45
- E. 5.26

Here C is the correct one. In Figure 4, we see that 73% of applicants chose the answer B instead.

The biggest number of correct answers got the question, which had also percentages in it. Namely:

*The price of a bicycle (EUR 250) was raised by 30%. If the price is lowered again by 30%, the price will be*

- A. EUR 200.50
- B. EUR 216.75
- C. EUR 227.50
- D. EUR 250.00
- E. EUR 265.30

Here the correct choice is again C, which 90.5% of applicants chose. In Figure 5, it may be seen that there was not a single student who left this question unmarked.

In 2016, the smallest number of points got the student applicants for their solutions to the problem with integrals (average 1.8 out of 10):

*Determine the area of the region enclosed by  $y = x^2 + 2x + 1$  and  $y = -x^2 + 1$ . Sketch the graph.*

Unfortunately, 20.6% of applicants did not provide an answer and 15.9% got 0 points for their solution. There were no 10 points worthy solutions at all. But in 2015 the most complicated problem (average 1.25 points out of 10) was:

*The apex angle of a right cone is 64 and circumference of the base is 126 cm. Find the lateral surface area and volume of that cone.*

This time, 19.1% of applicants did not try to solve this problem at all and 41.6% of students got 0 points.

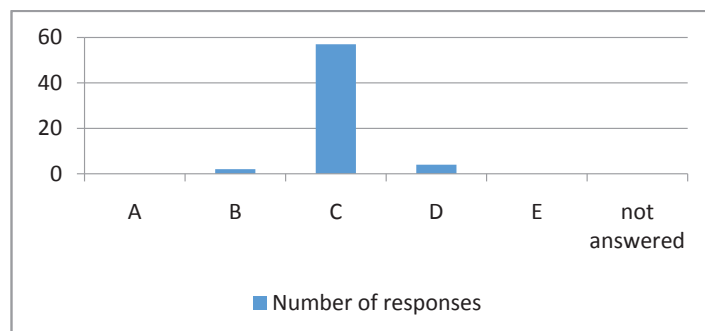


Figure 5. Answers of the least difficult question.

Only 1.1% of the examinees performed it perfectly. In both years the same problem appeared to be the easiest one to solve. The problem was:

*During drilling of a well EUR 60 was paid for first meter and EUR 50 more for every next meter than previous one. With bonus which was EUR 500 the payment was EUR 3910. How deep is the well?*

In 2016, the average points to receive were 5.84 points and the year before it was 4.85 (out of 10). Only 8% did not try to solve or got 0 points for that problem in 2016 and in 2015 the percentage was 15.8.

## Discussion

When comparing the average points for each question and problem between test results in 2015 and 2016, we see no big differences there. The student applicants also tend to make the same mistakes e.g. cannot find the common denominator, logical errors, errors in calculating percentage, difficulties in applying the formulas correctly etc. Also, lecturers at our university see the same mistakes in their students work. From (Madison *et al.*, 2015) we can find the results of university mathematics placement test results in Arkansas: the fewest correct student responses got the problems of solving an equation, arithmetic calculation and the choosing equivalent (simpler) expressions for the given expressions. Each of those was correctly answered by no more than 30% of the students.

It is also worrying that in many occasions there was blank page left – students even did not try to solve the problems. On average, every applicant left 2.1 questions unanswered. On the other hand, it is not surprising, considering that the student applicants are most likely being “rusty” after several months away from the subject. It also stood out that, for many reasons, those who have completed a school of general education recently can solve problems by relying on solutions of typical examples rather than by following the inner logic of a problem as the older student applicants tend to do. The test results also showed that there were no students who answered more than 19 questions (out of 20) correctly. As the admission test is based on mathematics state exam, it has problems and questions that are in national curricula and should be acquired by then. We have to conclude that students who enter the university have poor knowledge in mathematics. As admission test scores are reasonable predictors of grades in university mathematics and therefore predict the success in university (Madison *et al.*, 2015), it raises the question whether a big number of upper secondary school graduates are prepared for success in university mathematics course. Same conclusion

has been drawn in several studies in other countries (Rimkuvienė & Kaminskiene, 2012).

As there are many options for school graduates nowadays, e.g. it is possible to apply to different universities at the same time (abroad as well) or find a job instead of going to university, the potential students do not take candidacy too seriously (e.g. only 31.33% students arrived to take the test in 2014). The numbers show that many applicants were not planning on attending university at all. For example, in 2016 the number of students who actually entered university was 33 of 63 candidates who took the admission test. In 2015, the number was 37 (of 89) and as of today 21 of them are still students at our university.

## Conclusions

Approximately a quarter of student candidates in Estonian University of Life Sciences engineering specialties need to take the admission test in mathematics in order to apply. The average test score tends to be lower than in compulsory national mathematics exam. About 25% of applicants fail to receive the minimum 20 points of 100. The mathematics literacy seems to be insufficient. We see many mistakes including logical errors, errors in calculating percentage, difficulties in applying the formulas correctly etc. Each year the same problems and questions stand out that will get the highest and lowest number of points.

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