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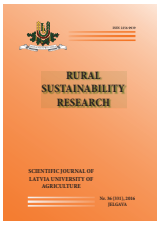

Common Diagnostic Test Results Over the Years

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Abstract. In this article, common test results over the years 2000 – 2016 are analysed. The test questions for new entrants were based on secondary school mathematics. The students took the test in the first lesson of the higher mathematics course. The test results were analysed by years, by tasks and by specialities, and their differences were found. The test results' dependence on state-exams score was studied and other types of dependence were looked at.

It was found that the test score has a strong correlation with a state-exam but with high school mathematics mark and with later higher mathematics course marks has very weak correlation. During these 16 years, the questions that have been the most difficult for students have not changed. The highest test scores were found among students who had chosen the most popular specialities (with the highest competition).

Keywords: common test in mathematics, teaching mathematics, basic competence in mathematics.

Introduction

The test of secondary school mathematics that first year students of Estonian University of Life Sciences take in their first seminar will be analysed. The test has been made every year since 2000 and has always had the same questions. The purpose of this study is to find out if there are any differences in the test results from year to year. These would imply different mathematics abilities of the new entrants. While the questions are the same from year to year, the school mathematics topics that are hard or easy for students can be found. Also, if there are any changes in topics' difficulty over the years. The test results are analysed by specialities. Their dependence on students' state-exam score is studied.

This study wants to find out if the test result reflects student's ability to follow a higher mathematics course.

Materials and Methods

Our cooperation in mathematics and statistics with mathematicians of agricultural universities of the Baltic and Nordic countries started in 1998. There have been ten joint Nordic-Baltic Agrometrics conferences since then. The term "Agrometrics" stands for "mathematics and statistics in the agricultural sciences and education". In 1999, Thomas Edlund presented the test at the second Agrometrics conference (Edlund, 1999) and after that, it was decided to give this test to all students in the Baltic States and Sweden.

The test contains 15 elementary tasks of secondary school mathematics. The students had to find the correct answers from among many alternatives. They could not use a calculator or other devices and the time allotted for the test was 45 min. The test was carried out in Sweden, Estonia, Latvia and Lithuania in the autumn of 2000 and after that, Estonian University of Life Sciences continues carrying out this test every year (Aruvee, 2001).

First five years (2000 – 2005) the test was given to four specialities´ students: Real Estate Planning and Evaluation, Geodesy, Water Management, Agricultural Buildings (Sikk, Aruvee, 2007). During that period, about 100 students took that test each year. In 2007, only Water Management speciality students (20 students) had to take the test. Starting

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Table 1

Average test results and state-exam grades over time

Tests	*Count*	*Average test score*	*Standard deviation*	**Average state-exam grade**
2000	95	6.73	2.64	40.40
2002	91	8.46	2.94	34.25
2003	100	8.93	3.28	63.06
2004	97	7.87	3.04	62.11
2005	108	8.42	2.87	52.40
2007	20	7.80	2.97	47.35
2008	204	6.25	2.63	48.49
2009	288	6.09	2.71	50.25
2010	357	5.99	2.60	51.56
2011	407	6.39	2.77	60.25
2012	380	6.32	2.88	57.41
2013	396	6.22	2.61	59.97
2014	304	7.18	3.09	51.63
2015	379	6.97	2.81	47.68
2016	303	6.59	2.81	52.39

from 2008, the test was given to all students to whom our department teaches mathematics. In addition to aforementioned specialities, the test was given to students of Economics and Animal Breeding. The number of students who take the test has been rising since 2008 (from 204 to 407 in 2011). From 2012, the number of entrants has been between 300 and 400. This test has been compulsory also to the faculty of technology students since 2015.

For this analysis, MS Excel was used for descriptive statistics and correlative analysis.

Results

Over the years, the average test results have been between 5.99 and 8.93 (Table 1). The maximum score is 15 points. In 2002 – 2005, the average score was better than in the following years. It can be explained by having less students and by specialities having higher expectations in mathematics knowledge.

In 2014, the average score was quite high - 7.18. Starting from that year, all students have to take the state-exam in mathematics and it might be the reason why they know mathematics better. From 2015, a number of new university entrants have entered via an entrance test. Their knowledge was not so good and that is why the average score was a bit lower in 2015 (6.97) than in 2014 and, unfortunately, in 2016 the average test result was still lower (6.59). Nowadays the number of people who graduated from secondary school many years ago has grown year by year, and they have forgotten many things taught in high school.

The test results by specialities (Figure 1) show that Forestry students have had one of the lowest average scores over the years. At the same level are also Animal Breeding and Engineering students' results.

From 2011, Estonian University of Life Sciences has had an agreement with Aviation Academy to teach their students basic subjects. The highest average yearly test results were between 8.29 and 9.29 (Figure 1). Unfortunately, in 2016, the average test result was 7.82. That means that Aviation Academy students' ability lowers every year. The average test result of Economics and Buildings specialities' students have been (mostly) increasing after 2012.

A very clear influence to the test result is how big the competition among university entrants is and also how popular the speciality is in the society. Here two examples can be given:

1. In the 90-s, there was very active land privatization and the speciality Real Estate Planning was very popular. 50 students entered the university every year.

When comparing the average score of two specialities from the same department, there was one or one and a half point higher score in Real Estate Planning than Geodesy (Figure 2). In 2013, one new speciality - Geomatics - was founded. It consists of combination of these two specialities and is opened

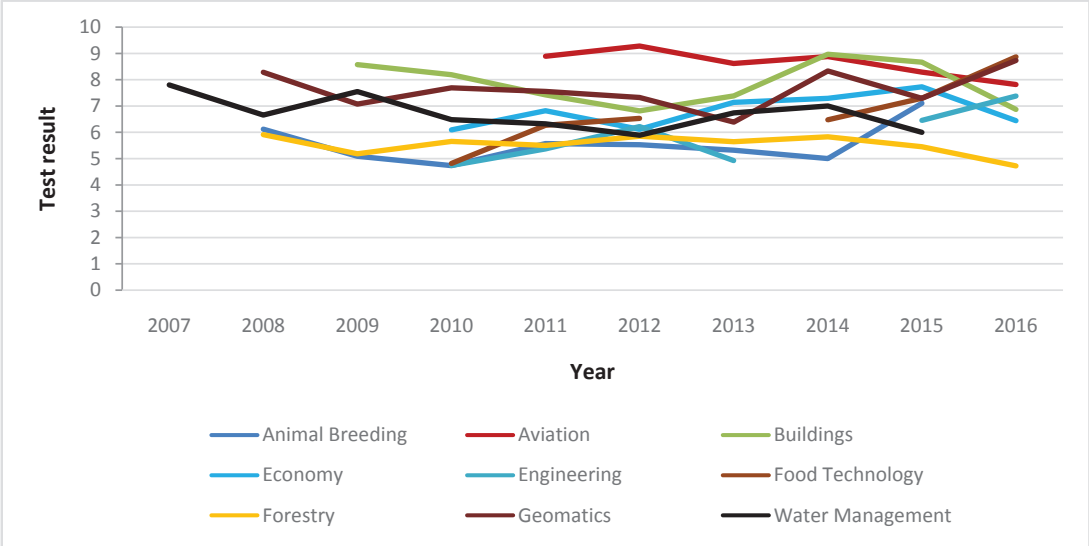

Figure 1. Changing of average test results by specialities.

only if there are enough students. Today, less than 30 students are being educated in this speciality.

2. Nowadays the highest competition between entrants to our university is in Food Technology speciality. Their average test result has risen over the years. In 2010, it was 4.82 and in 2016 it has risen to 8.87. Food Technology has become more popular among students because of the scholarship given to them.

The Economics speciality has always had high competition between entrants and the test score average varies from 6.1 to 7.7. It has risen every year since 2010.

When there is little interest in applying, the university accepts all students who wish to study and does not assess students' ability. In 2010, a new speciality, Biosystems Engineering, was opened. But it was not very popular among students. There were 14 students and their average test score was 4.74. The last year when students could apply was 2013, and their average test score was 4.92. When the average test score is quite low, then one can believe that there is a big number of students who have left the course.

Generally it is known that different test scores' and school marks' distribution follow normal distribution. In the graph (Figure 1), the black line is the average test score distribution, and it can be seen from the graph that for several years the average test score has followed normal distribution. The overall average test score was 6.57 and most scores were between 3 and 10. A test score above 13 points is quite rare (4% of responses), but at the same time, a test score of 3 points or less appear frequently (12% of responses). Every year there were students who got 0 points for the test. The test score distribution for 2014 differs from normal distribution. In that year, a

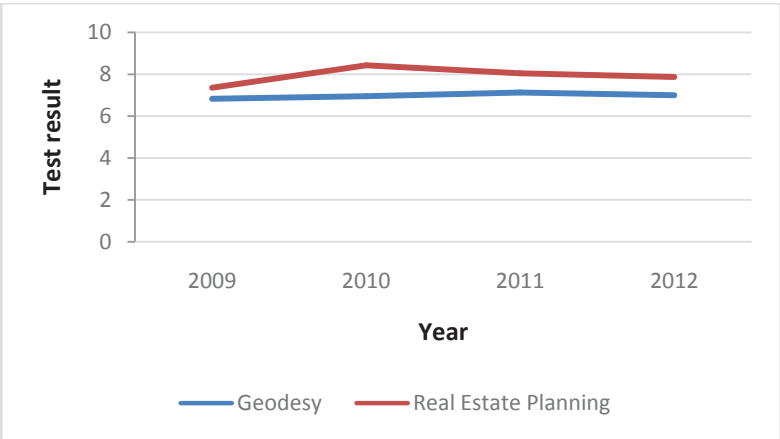

Figure 2. Comparing Geodesy and Real Estate Planning students' test results.

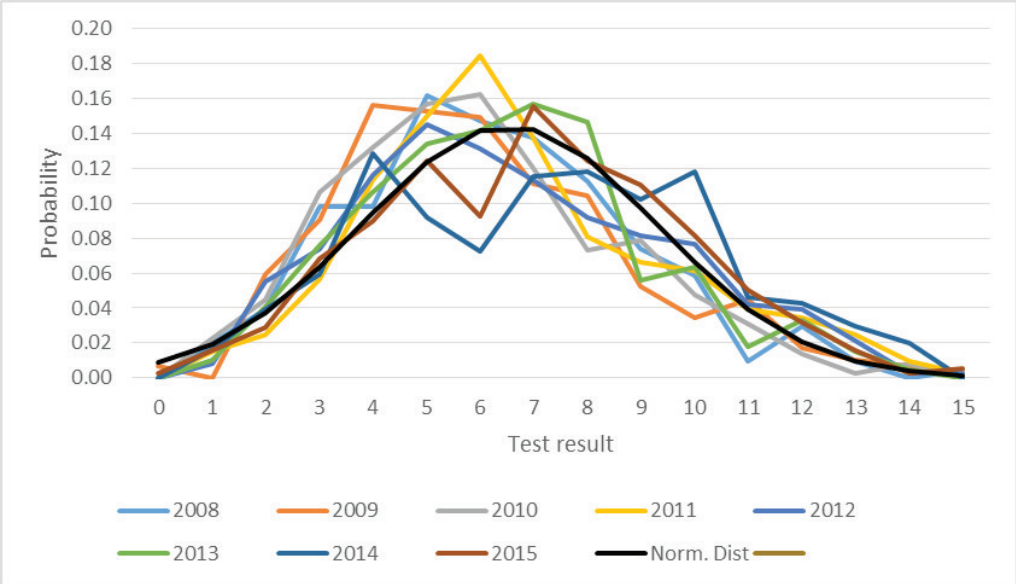

Figure 3. Test points' distribution.

test score of 4 and 10 points was more common than 6 or 7 points.

Different analyses have been used to determine what influenced the test result. The correlation coefficients between secondary school mathematics grade, state-exam grade and the test result were calculated. Positive correlation between school grade and state-exam grade (r=0.47), and between state-exam grade and the test result (r=0.57) were found. The correlation between the test result and school grade was lower. The positive correlation shows that who got a better result in state-exam was more likely to get a better test result.

In 2007, the test results and higher mathematics course marks were compared to see if there is any dependence (Sikk, Aruvee, 2007). Only a weak correlation (0.3) was found. A good mark in mathematics depends mostly on the ability of a student and how seriously the student takes his/her studies. A good test result does not necessarily lead to a good mark in the higher mathematics course.

The test scores were analysed by tasks. In the test, there were 15 questions with following topics: 1 – operations with fractions; 2 – simplification; 3 – a general solution of square root function; 4 – raising to a power; 5 – logarithmic function; 6 – root of an equation; 7 – solution of inequality; 8 – solution of quadratic equation; 9 – trigonometry; 10 – equation of a line; 11 - square root function; 12 - solution of inequality with a valuation; 13 – percentage; 14 – simplification; 15 – Pythagoras theorem.

The best-answered test task, on average, was Pythagoras theorem; good results were also in tasks 1, 3, 6 and 13. More than half of the students did not find the right answers for tasks 5, 7, 8, 9, 11 and 14. Trigonometry was a big problem, students were not able to decide which angle is positive, could not extract a root, could not use auxiliary formulas in simplification and did not know even general solution of a quadratic equation (Aruvee, 2001). The answers have not changed over the years.

Here are the worst solved tasks 7, 9 and 11:

7. Which of the following inequalities is correct?

A. $\frac{1}{6} = 0{,}166$

B. $\frac{1}{6} \leq 0{,}166$

C. $\frac{1}{6} > 0{,}166 \geq \frac{1}{5}$

D. $\frac{1}{6} > 0{,}166$

E. None of the above

9. Which of the following value is positive?

A. $\cos(\frac{-3\pi}{4})$

B. $\sin(\frac{-3\pi}{4})$

C. $-\sin(\frac{-3\pi}{4})$

D. $-\tan(\frac{-3\pi}{4})$

E. None of the above

11. $\sqrt{5^2 + (-a)^2} =$

A. 5 + a

B. -5 +a

C. 5 – a

D. -5 – a

E. None of the above

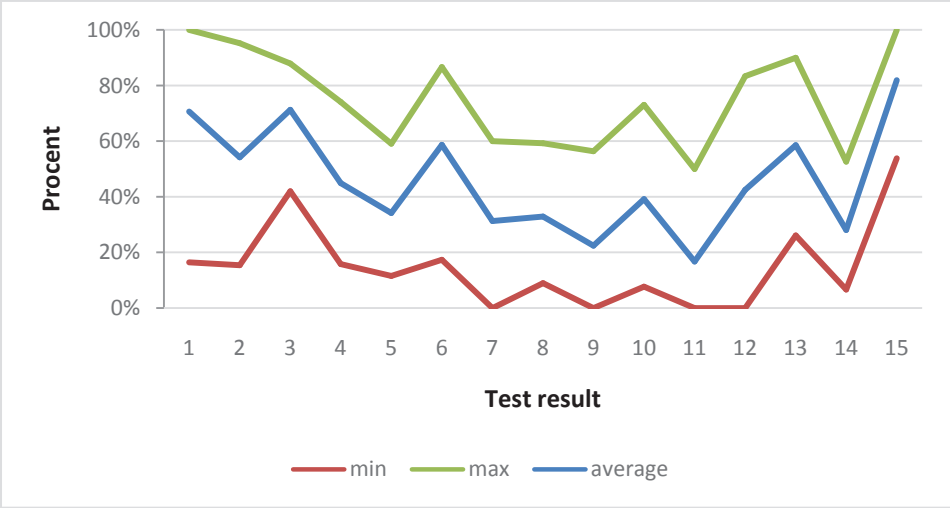

Figure 4. Variation of test task points.

Students from different specialities answered test questions very differently. The variability of first (operations with fractions) and second (simplification) task was the biggest (Figure 4). The specialities Animal Breeding and Engineering answered these questions poorly, only 16% to 30% of the students knew the right answer, while the other specialities' students gave right answers much more often, 70% or more of the students.

The difference between the minimum and maximum percentage is the lowest for the 15th task (variability is 46% to 100%).

Conclusion

The new national requirement to sit a mathematics state-exam that was introduced in 2014 raised the average test score relatively high. A positive correlation between the mathematics state-exam score and the test result was found.

The University of Life Sciences' most popular specialities are Food Technology and Economics. These two specialities have seen the biggest number of applications as well as the highest test scores.

The state-exam mark correlates with the test results. Although the test score usually follows a normal distribution, in 2014, it did not. Then, there was a bigger number of test results with a score of 4 or 5 points and 8 – 10 points than normally.

The best answered test questions over the years were: 1 – operations with fractions, 3 – a general solution of square root function, 6 – root of an equation, 13 – percentage, 15 – Pythagoras theorem.

A good test result does not necessarily lead to a good mark in the higher mathematics course. The latter depends mostly on the ability of a student and how seriously the student takes his/her studies.

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