Achievement in university entrance examination relative to attendance in preparation classes and type of secondary school completed: a case study of geodesy undergraduate candidates

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ABSTRACT

This paper is a review of the mathematics test taken by undergraduate candidates in the university entrance examination for enrollment in the geodesy undergraduate course offered at the Faculty of Architecture, Civil Engineering and Geodesy, University of Banja Luka, Bosnia and Herzegovina, in the academic year 2012/13, and it analyses the relevance and impact of preparation classes on candidate achievement. It contains an analysis of the candidates' mistakes according to problem, achievement discrepancy according to problem, as well as differences between the candidates relative to the secondary school completed and secondary school grade point average. The findings of the analysis are presented using descriptive statistics and relevant statistical tests of the SPSS statistical analysis software package. The correlation of achievement in the entrance examination with attendance in the preparation course reveals a strong statistical significance in regard to candidate achievement in the mathematics test ($p = 0.024$).

Keywords: preparation classes; entrance examination; mathematics education, secondary school grade point average

1. INTRODUCTION

It has long been observed that in the last ten years or more, the scholastic aptitude of candidates competing for enrollment in technical departments and universities in Bosnia and Herzegovina has significantly changed, with the general knowledge they gain in secondary school, particularly their knowledge of mathemathics and physics, considerably more inferior than before. This trend has coincided with the state of things in the adjacent countries, e.g. Serbia, Croatia and Bosnia and Herzegovina (Kadijević, Marinković, and Brkić 2004; Romano, 2013).

Consequently, this has impacted the candidates' achievement in the core mathematics and physics units taken as part of undergraduate programmes, as well as their capability to apply their knowledge of mathematics and physics when it comes to specialised modules (Kosić-Jeremić 2012; Rozov 2004; Roddick 2003).

The ability to use mathematics in other disciplines is generally expected of all science and engineering students. Anecdotal evidence suggests that many students lack this ability. Science and engineering degrees typically require students to study mathematics as a subject in its own right, with the expectation that students will be able to use the skills and knowledge acquired from their mathematics units in other disciplines (Kosić-Jeremić 2012).

There are various papers the authors of which assume that students have a problem applying mathematics. Gill (1999a, 1999b), for example, has studied the problems students of physics and engineering have with mathematics. Jackman et al. report on a project involving assessment tasks designed to improve the ability of students to apply/use mathematics in context (Jackman, Goldfinch, and Searl 2001). Britton (2006) gave reports on the development and piloting of an instrument which can be used to research the ability of students to apply mathematical skills and knowledge to other disciplines. The instrument consists of mathematical problems set in various contexts. All the problems involve exponential and logarithmic functions, and are based on scenarios from physics, microbiology and computer science.

However, there are very few papers on the issue of entrance examinations, more precisely, papers that analyse candidate achievement in university entrance examinations. Our primary focus here is technical departments and candidate achievement in the mathematics part of the locally administered entrance examination.

The first generation of students to follow a curriculum on the Bologna recommendations at the Department of Geodesy of the Faculty of Architecture, Civil Engineering and Geodesy matriculated in the academic year 2007/08. In the academic year 2012/13, each of the three departments admitted 40 undergraduate students, with completed four-year secondary education. A total of 229 candidates applied for enrollment, of whom 81 to the Architecture Department, 48 to the Civil Engineering Department, and 100 to the Geodesy Department.

2. SAMPLE AND ORGANISATION OF RESEARCH

The paper below reviews the achievement of the candidates who applied for enrollment in the geodesy course in the academic year 2012/13, their secondary school grade point average (GPA) and achievement in the entrance examination, with a focus on the relevance of attendance in preparation classes. Each candidate GPA could be assigned a maximum of 50 points (GPA multiplied by 10). They could also win 50 points for their achievement in the entrance examination, consisting of 10 mathematics problems, of which each was assigned 5 points. The candidates needed to win at least 15 points to pass the entrance examination. A total of 100 candidates applied to compete in the entrance examination for enrollment in the geodesy course, of whom 97 from Bosnia and Herzegovina and 3 from abroad (with one from Serbia, Croatia and Montenegro each).

Since 2008, the Faculty of Architecture, Civil Engineering and Geodesy in Banja Luka has held preparation classes in the subjects taken in the entrance examination (mathematics); the preparation classes take place during the month of June (30 classes). Instruction is offered to prospective undergraduates over two consecutive weeks, who attend three classes each weekday. During the preparation classes the candidates are instructed in the areas basically revising those covered in the first and second year of secondary school, which are also tested in the entrance examination.

The subject matter covered in the preparation classes includes polynomials; linear function; linear equations and linear inequalities; problems reducible to equations with one unknown and systems of two linear equations with two unknowns; ratios and proportions; absolute value of real numbers; power rules; root rules; quadratic functions, equations and inequalities; equations reducible to quadratic equations; systems of one linear equation and one quadratic equation or two quadratic equations with two unknowns; exponential functions, equations and inequalities; logarithmic functions, equations and inequalities; trigonometry, plannimetry and stereometry.

In June 2012, a total of 51 candidates took the preparation classes. Out of 100 candidates competing for matriculation, 43 passed the entrance examination.

2.1 Research objectives

One objective of the research was to determine the relevance of the mathematics preparation course for the candidates enrolling in the geodesy course at the Faculty of Architecture, Civil Engineering and Geodesy in Banja Luka. The additional objectives were ascertaining which areas of basic mathematics were the most problematic for the candidates, which secondary schools produced the strongest candidates and in which disciplines and areas, and the level of quality of secondary school mathematics teaching.

2.2 Subject matter and methods

A research database was created and fed all the relevant parameters. The obtained results were processed and presented using descriptive statistics and relevant statistical tests of the SPSS statistical analysis software package (originally: Statistical Package for the Social Sciences, later modified to read Statistical Product and Service Solutions) (Preradović and Đajić 2011).

2.3 Research analysis and results

The secondary schools completed by the competing candidates were grouped in four categories: Gymnasiums/Grammar schools, Civil engineering schools (including vocational schools), Other technical schools and Other schools.

Table 1 shows the candidate structure according to secondary school completed.

Two mathematics tests were used in the entrance examination, each containing ten problems. Each problem was worth 5 points. The two sets were equal in terms of content and difficulty; hence, only the problems from one set are given as illustration in this paper, whereas the examination achievement analysis covers both sets of problems.

The candidates' achievement in the entrance examination was analysed according to problem. In the analysis we also took account of the types of mistakes the candidates made solving problems from different areas, as well as the achievement discrepancy between the candidates who took the preparation classes and those who did not.

The candidates who had completed 'Other schools' had the highest secondary school GPA (41.93), followed by the gymnasium/grammar school graduates (41.22). The third were the candidates from the 'Other technical schools' group (38.97), and the fourth graduates of civil engineering schools (38.95), as shown in Table 2.

The Kruskal-Wallis test showed no strong statistical significance in terms of the geodesy undergraduate candidates' secondary school GPA, $\chi^2 = 3.743$, SS = 3, $p = 0.291$. The Mann-Whitney U test was also used, but it failed to show a strong statistical significance of GPA between the candidates who graduated from gymnasia (Md = 41.91, n = 36), civil engineering schools (Md = 39.09, n = 37), other technical schools (Md = 39.68, n = 12) and other schools (Md = 43.33, n = 15), with a low R (effect size).

3. ACHIEVEMENT ANALYSIS (ACCORDING TO PROBLEM)

Figure 1 show the average number of points won for individual problems relative to attendance in the mathematics preparation course.

In each problem 0 points is given for incorrectly solved or unsolved problem and 5 points is given for completely correctly solved problem.

Given below is an analysis of the individual problems contained in the test:

Problem no. 1. Define the values of *m* and *t* so straight line $y = \frac{m+t}{2t} \cdot x + \frac{4m-5t}{m+1}$ is perpendicular to straight line $y = -\frac{1}{3} \cdot x + 1$ and intersects the *y*–axis at point 2. After defining the *m* and *t* values, sketch the straight line.
Solution: *m*= 2, *t*=2/5 Straight line: *y*=3*x*+2.
This problem tested the candidates' knowledge of linear functions and their properties. Also, following the determination of the required parameters, the problem needed to be reduced to a system of two linear equations with two unknows; thereby, the problem covered two distinct areas of mathematics.
Points for partial solutions of this problem were awarded as follows:
1 point – not given
2 points – problem correctly modelled, one of the required parameters determined
3 points – both parameters determined, the function graph incorrect or missing
4 points – trivial error found in the solution process, leading to incorrect determination of one of the parameters; straight line sketched, demonstrating the candidate's familiarity with the properties of linear functions
Analysis: The candidates won an average 1.71 points for this problem, with a statistical deviation of 2.11. The candidates who took the preparation course won an average 2.53 points for this problem, as opposed to those who did not (0.86) (Figure 1). Those candidates who passed the entrance examination won an average 3.19 points, with a statistical deviation of 2.14, and the candidates who both took the preparation course and passed the entrance examination (a total of 28) won 3.64 points for this problem, with a deviation of 1.97.
Only 23 candidates solved this problem completely correctly, whereas as many as 56 won 0 points. Linear functions are taught in the first grade of secondary school, even the final grade of primary school. Also, it was predominantly graduates of gymnasia/grammar schools who solved this problem completely correctly (14); the candidates who passed the examination won an average 3.68 points for this task.

Problem no. 2. Simplify the following expression, $\left(\frac{3a-15}{a^2-a-20}\right)^{-1} : \frac{a+4}{27}$.
After the expression is reduced, it equals 9.
This problem tested the candidates' knowledge of power rules and the reduction of polynomials to lowest terms.
No points were awarded for incomplete solutions of this problem, except in the case of a candidate who solved the problem correctly but failed to suply the final result, i.e. reduce the fraction, winning 4 points.
Analysis: The candidates won an average 2.53 points for this problem. Those candidates who took the preparation classes won an average 3.14 points for this problem, and those who did not only 1.90 (Figure 1). Those candidates who passed the entrance examination won an average 4.02 points (statistical deviation 1.97), and the candidates who both took the preparation course and passed the examination won 3.93 points for this problem, with a deviation of 2.09.
Overall, this problem won the candidates the highest average number of points. 50 candidates (of whom 23 gymnasium/grammar school graduates and 17 civil engineering school graduates) solved this problem completely correctly. The gymnasium graduates who passed the examination won an average 4.32 points for this problem.

Problem no. 3. Determine the value of parameter $m \in R$, for which the following function, $y = (m+1) \cdot x^2 + 2 \cdot (m-1) \cdot x + 4m - 1$, is positive for every $x \in R$. Sketch a graph of the given function for an arbitrary m falling within the determined range.

This problem tested the candidates' knowledge of quadratic functions and their properties, as well as their ability to solve quadratic equations and inequalities.

Solution: Provided $D < 0$ and $a > 0$, $m \in \left(-1, \frac{1}{3}\right)$.

Points for partial solutions of this problem were awarded as follows:
1 – only initial parameters correctly modelled (a>0 i D<0)
2 – initial parameters correctly modelled; a mistake made in the process of solution of quadratic inequality D<0
3 – initial parameters correctly modelled; inequality correctly solved; an error found in the final solution; a graph of the function missing
4 – problem correctly solved; a graph of the function for an arbitrary m from the determined range missing
Analysis: The candidates won an average 0.82 points for this problem, with a statistical deviation at 1.53. Those candidates who passed the entrance examination won an average 1.60, with a deviation of 1.93; those candidates who took the preparation course won an average 1.22 points for this problem, and those who did not only 0.41 (Figure 1). The average points won by the candidates who both took the preparation course and passed the entrance examination was 1.86, with a deviation of 2.07.
Only 5 candidates won the maximum 5 points, of whom 4 gymnasium graduates and one a civil engineering school graduate. As many as 72 candidates won 0 points for this problem. This was a surprisingly bad score, as the problem tested rather basic concepts and operations.

Problem no. 4. Solve the following equation, $\frac{2}{3^{-2x}} + \frac{3}{2^{-2x}} = \frac{5}{6^{-x}}$.

As can be seen, this problem tested the candidates' knowledge of exponential equations. The problem had two solutions, $x_1 = 0$ and $x_2 = 1$.
Points for partial solutions of this problem were awarded as follows:
1 – not given
2 – not given
3 – only one solution found, the second missing
4 – penultimate step in the solution process missing
Analysis: The candidates won an average 1.90 points for this problem, with a statistical deviation of 2.40. The candidates who passed the entrance examination won an average 3.74, with a deviation of 2.13. The candidates who took the preparation course won an average 2.27 points for this problem, and those who did not only 1.51 (Figure 1). The average points won for this problem by the candidates who both took the preparation course and passed the entrance examination was 3.61 (statistical deviation 2.18).
Of the total number of candidates, 36 won the maximum 5 points, of whom 16 were gymnasium graduates and 15 civil engineering school graduates. As many as 61 candidates won 0 points for this problem.

Problem no. 5. Calculate 20% of $2\log_5 \sqrt{27} \cdot \log_{\frac{1}{3}} \sqrt[3]{25} + \left(\frac{1}{27}\right)^{-\frac{2}{3}} - \left(1 + 16^{0.25}\right) \cdot 2^{-1}$

Problem number five required the solution of the given expression, which the candidates could do only if they were familar with power and root rules as well as logarithms. The final value of the whole expression is $\frac{17}{2}$. 20% of this value is $\frac{17}{10}$.
No points were awarded for partial solutions of this problem.
Analysis: The candidates won an average 0.60 points for this problem, with a statistical deviation of 1.63. The candidates who passed the entrance examination won an average 1.40, with a deviation of 2.27. The candidates who took the preparation classes won an average 0.98 points for this problem, and those who did not only 0.20 (Figure 1). The average score for this problem of the candidates who both took the preparation classes and passed the entrance examination was 1.79, with a statistical deviation of 2.44.

It was this problem that the greatest number of candidates failed to solve; namely, as many as 88 won 0 points. Only 12 candidates succeeded in solving this problem completely correctly, of whom 5 from grammar schools, 5 from civil engineering schools and 2 from other technical schools. In conclusion, the candidates' knowledge of these concepts and operations is rather poor.

Problem no. 6. Solve the following inequality, $\frac{x-1}{x+2} \geq \frac{2}{1-x}$.

The inequality needed to be reduced to the following expression, $\frac{x^2+5}{(x+2)\cdot(1-x)} \leq 0$, after which it could be solved either using tables, or one could see immediately it was equivalent to $(x+2)\cdot(1-x) \leq 0$. Again, this problem required the knowledge of quadratic functions and of how to solve quadratic inequalities.
Points for partial solutions of this problem were awarded as follows:
1 – inequality correctly reduced; a fundamental error made in the rest of the solution process
2 – inequality correctly reduced; an error made in the rest of the solution process
3 – error made while reducing the expression; the rest of the solution process correct. Evident familiarity with the concepts tested.
4 – the final result incorrectly written, i.e. angular brackets put in inapproprate places (the result is a union of open intervals)
Analysis: The candidates won an average 2.00 points for this problem, with a statistical deviation of 2.22. The candidates who passed the entrance examination won an average 3.44, with a deviation of 2.15. The candidates who took the preparation course won an average 2.22 points for this problem, and those who did not only 1.78 (Figure 1). The average score for this problem of the candidates who both took the preparation classes and passed the examination was 3.32, with a statistical deviation of 2.22.
Thirty candidates succeeded in solving this problem completely correctly, of whom 13 from gymnasiums, 12 from civil engineering schools – this being the first instance of civil engineering school graduates surpassing gymnasium graduates, 4.07 and 3.09 respectively – and the average score of candidates from other schools was 3.33. Fifty candidates won 0 points for this problem.

Problem no. 7. Find all solutions of the equation $3tg^2 x - \frac{1}{\cos^2 x} = 1$.
The entrance test typically contains one or two trigonometry problems. In this particular case, the candidates needed to find all solutions of the given trigonometric equation.
Solution: the equation is reduced to $\sin^2 x = \frac{1}{2}$, giving the following results, $x_1 = \frac{\pi}{4} + k\pi$ and

$x_2 = \frac{3\pi}{4} + k\pi$ $(x \in Z)$. The solutions may be written as four results (for period $2k\pi$).
Points for partial solutions of this problem were awarded as follows:
1 – equation correctly reduced, zeros of the quadratic equation (values of the sinx function) found
2 – equation correctly reduced; erroneous values of the sinx function in the final results. One of the four requested results correct.
3 – equation correctly reduced; two results missing
4 – equation correctly reduced; one result incorrect, the other three correct
Analysis: The candidates won an average 0.78 points for this problem, with a statistical deviation of 1.57. Those candidates who passed the entrance examination won an average 1.49, with a deviation of 2.00. The candidates who took the preparation course won an average 0.57 points for this problem, and those who did not only 1.00 (Figure 1). The average score for this problem of the candidates who both took the preparation classes and passed the entrance examination was 1.04, with a statistical deviation of 1.91.
This problem was completely correctly solved by 7 candidates only, of whom 5 from gymnasiums and 2 from civil engineering schools.

Based on our experience from the entrance examinations several years back, the authors are aware of the fact that the candidates usually have the poorest knowledge of trigonometry, as evidenced in the preparation classes.

Problem no. 8. Given the following values for triangle ABC, side $a = 2cm$ and angles $\gamma = 60^0$ and $\beta = 75^0$, calculate the values of its other basic elements and the radius of the circle circumscribed around it.
This is a planimetry problem, whose solution required the application of the Sine Rule.

Solution: $\sin 75^0 = \sin(45^0 + 30^0) = \frac{\sqrt{6}+\sqrt{2}}{4}$, so $b = \sqrt{3}+1$ *cm*, *c*=$\sqrt{6}$ *cm*, *R*=$\sqrt{2}$ *cm*.

Points for partial solutions of this problem were awarded as follows:
1 – law of sines correctly applied
2 – 2 required values correctly calculated
3 – 3 required values correctly calculated. The candidate incapable of presenting the obtained expression
4 – all required values except one correctly calculated. The candidate used the formula needed to calculate the sine value of the sum of two angles ($\sin 75^0$)

Analysis: The candidates won an average 0.70 points for this problem, with a statistical deviation of 1.55. Those candidates who passed the entrance examination won an average 1.58, with a deviation of 2.04. The candidates who took the preparation course won an average 1.00 points for this problem, and those who did not only 0.39 (Figure 1). The average score for this problem of the candidates who both took the preparation course and passed the entrance examination was 1.75 (statistical deviation 1.97).
This problem was completely correctly solved by 8 candidates only, of whom 5 from gymnasiums and 3 from civil engineering schools. The achievement was similar to that for the previous problem, which is hardly surprising, since this one also required trigonometric knowledge.

Problem no. 9. Find the area of the trapezium whose parallel sides equal 24 *cm* and 10 *cm*, and non-parallel sides 13 *cm* and 15 *cm*.
Typically, the test contains a relatively simple planimetry or stereometry problem, whose solution does not require trigonometric knowledge. The candidates usually need to find the area of a triangle or quadrangle, or the volume and area of well-known solid bodies (prism, pyramid, cone, cylinder etc.).
Solution: The area of triangle EBC is 84 cm^2 (Heron's formula), hence *h*=12 *cm*, and consequently the area of the trapezium $P = \frac{a+c}{2} \cdot h = 204 cm^2$.

Points for partial solutions of this problem were awarded as follows:
1 – not given
2 – Heron's formula correctly used
3 – incorrect height
4 – area expressed in inappropriate measurement unit (*cm* instead of cm^2)

Analysis: The candidates won an average 1.15 points for this problem, with a statistical deviation of 2.02. Those candidates who passed the entrance examination won an average 2.44, with a deviation of 2.34. The candidates who took the preparation course (a total of 51) won an average 1.33 points for this problem, and those who did not 0.96 (Figure 1). The average score won for this problem by the candidates who both took the preparation classes and passed the examination was 2.43 (statistical deviation 2.39).
This problem was completely correctly solved by 19 candidates only, of whom 10 from gymnasia, 6 from civil engineering schools and 3 from other schools. The authors expected a better achievement than this with regards to this problem.

Problem no. 10. The scale of a geographic map is 1: 1 200 000. What is the map distance, expressed in *cm*, between two places whose distance in actuality is 480 km?

This problem tested the candidates' knowledge of the rule of three, a must for geodesy and surveying undergraduates.

Solution: $x = \frac{480000}{1200000} m = 0.4m$, i.e. 40 *cm*.

No points were awarded for partial solutions of this problem, except in the case of a candidate who solved it correctly but expressed the distance in cm^2, thus winning 4 points.

Analysis: The candidates won an average 1.19 points for this problem, with a statistical deviation of 2.13. Those candidates who passed the entrance examination won an average 2.19, with a deviation of 2.49. The candidates who took the preparation course (a total of 51) won an average 1.08 points for this problem, and those who did not 1.19 (Figure 1). The average score for this problem of the candidates who both took the preparation classes and passed the examination was 1.61, with a statistical deviation of 2.38.

This problem was completely correctly solved by 23 candidates, of whom 6 from gymnasia, 9 from civil engineering schools and 8 from other schools. A better score had been anticipated in the case of this problem as well, which we also considered the easiest one; therefore, no points were awarded for partly correct solutions.

The candidates from gymnasia who passed the entrance examination won a mere 1.32 points for this problem, those from civil engineering schools 2.67, and those from other technical schools 5.00.

4. DISCUSSION

Out of 51 candidates who took the preparation classes, 28 (54.9%) passed the entrance examination. Only 15 (30.6%) candidates passed the entrance examination without previously attending the preparation classes offered at the Faculty (Table 3). It is worth mentioning that the candidates prepare for the examination either independently or with the help of a tutor. Combinations are also common, which include all these modes, as indicated by the successful candidates in an anonymously administered survey. The Yates' chi-squared test showed a statistically significant correlation between attendance in the preparation classes in mathematics and achievement in the mathematics test, χ^2 (1, 100) = 5.065, p = 0.024, fi = 0.245.

The average entrance examination score was 13.38, with a standard deviation of 11.97. The maximum score won in the test was 46.

The candidates who passed the entrance examination won an average 24.98 points, with a deviation of 8.31; those who failed it won only 4.63 points, with a deviation of 4.50. The candidates who took the preparation classes and passed the examination won 24.78 points, with a statistical deviation of 7.68. Those who took the preparation course and failed the examination won 5.83 points (statistical deviation 4.36).

The candidates who took the preparation course were better at solving eight out of ten problems, whereas those who did not were more successful at solving problems 7 and 10 (Figure 1). They had the highest average score for problems 2 (3.14 points on average) and 1 (2.53 points on average), and the lowest average score for problems 7 (trigonometry; 0.57 points on average) and 5 (power and root rules, logarithms; 0.98 points on average). The candidates who did not take the preparation classes also had the highest average score for problems 2 (winning an average 1.90 points) and 6 (1.78 points), and the lowest average score for problems 5 (power and root rules, logarithms; 0.20 points on average) and 8 (trigonometry; 0.39 points).

The Mann-Whitney U test showed a significant difference between the mean values of the entrance examination achievement of gymnasium graduates (Md = 18.00, n = 36) and civil engineering school graduates (Md = 10.00, n =37), U = 489, z = -1.96, p = 0.05, r = 0.2290); gymnasium and other technical school graduates (Md = 9.50, n =12), U = 113, z = -2.458, p = 0.014, r = 0.355); and gymnasium and other school graduates (Md = 7.00, n =15), U= 148, z = -2.53, p = 0.011, r = 0.354), with a medium effect size (r) calculated. The test failed to show a significant discrepancy between the entrance examination achievement of graduates of vocational or other schools (civil engineering schools, other technical schools, other schools).

5. CONCLUSION

This paper presents the achievement of candidates who competed for matriculation in the undergraduate geodesy course offered at the Faculty of Architecture, Civil Engineering and Geodesy, University of Banja

Luka, in June 2012, based on their secondary school GPA and the points won in the entrance examination, with a focus on the effects of the preparation classes taken.

Based on two parameters, a passing score in the entrance examination and attendance in the mathematics preparation classes, a statistical significance $p = 0.024$ was obtained in regard to the achievement in the entrance examination. Namely, the candidates who took the mathematics preparation course were more successful at solving the problems and had a better score in the entrance examination.

Also, by comparison with the other candidates, gymnasium graduates had the highest average score in the test, along with the greatest average number of correctly solved problems.

The authors have conducted a similar analysis of the achievement of candidates competing for entrance in the Civil Engineering Department, with somewhat different findings. Namely, that analysis failed to show the statistical significance of attendance in the mathematics preparation course for achievement in the entrance examination, unlike the physics preparation classes (Preradović et. al. 2013). This is possibly attributable to the smaller sample and the smaller number of candidates analysed by the authors in the cited paper.

However, following our individual analysis of the problems given in the test and given the average number of points won for the problems, viewed independently, and the errors the candidates made while solving each problem individually, the general conclusion is we cannot be content with the candidates' achievement.

A candidate needs to win 15 points, i.e. 30% of the test, to pass the entrance examination. We find this unsatisfactory, given the fact points were awarded for partly incorrectly solved problems. We reiterate this for the reasons emulated in the introduction, the students' inability to pass their examinations during the studies and the failure to acquire the mathematics and physics subject matter taught in technical courses. This has also been proven by studies (Kosić-Jeremić 2012; Gill 1999a, 1999b; Britton 2007), with students unable to demonstrate sufficient knowledge of mathematics or apply previously supposedly acquired knowledge when dealing with specialised subjects. E.g., Britton (2006) showed in her research that students of physics, microbiology and IT had difficulty when it came to logarithmic and exponential functions.

It is necessary to widen the scope of this research to include other disciplines and skills, such as computer application and students' computer literacy (Kozina, G.Dukić and D.Dukić 2012) and their relevance for the studied achievement, take into account student satisfaction with the reformed higher education as offered in technical deparments and universities (Crnjac Milic, Martinovic and Fercec 2007), and compare the previous curriculum and teaching methods to those currently used (Bologna system).

Torenbeek, Jansen and Hofman (2011) found direct positive effects for prior achievement and the pedagogical approach on first-year study success, meaning that students who were more successful in the past, are more successful in the first year at university.

Achievement is directly affected by the perceived fit between school and university. A better fit may ease the transition of students to university, through which they are more motivated to study, resulting in better performance. The results further showed that a more student-centred pedagogical approach in the first period in undergraduate programmes is related to greater skill development, especially in terms of basic and collaboration skills.

5.1 Recommendations on how to improve the quality of secondary school education

It is necessary to closely examine the subject matter of mathematics taught in secondary schools and indicate deficiencies in the teaching of specific areas. We recommend that preparation classes be held over a longer period of time, to allow prospective undergraduates more time to process, acquire and revise each area and also do homework, which should have a positive effect on their achievement in the entrance examination. Also, it would be useful for technical departments that do not currently offer preparation classes to introduce an obligatory mathematics preparation course or a course in basic mathematics at the beginning of every academic year, for the purpose of revision of secondary school mathematics subject matter, essential for attending and mastering higher mathematics (mathematics modules taught in technical/engineering departments). It is necessary to run a detailed analysis of student achievement during studies based on the type of secondary school completed, and to hold thematic meetings with teachers from vocational schools to direct attention to the specific areas the candidates have proven to have difficulty with in the entrance examination and during studies. This type of analysis should make use of not only traditional techniques but also of advanced ones (e.g., data mining), in order to indicate causes and effects over an extended time period. One of the outcomes ought to be revised mathematics syllabi for secondary schools. Also, using computers and contemporary information aids in mathematics classes and university preparation courses would significantly increase the quality and permanence of acquired knowledge (Milovanović, Obradović and Milajić 2013; Salwani, Salleh and Zakaria 2012; Oktaviyanthi and Supriani, 2014).

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Table 1. Candidate structure according to secondary school and sex.

Candidate sex		Type of secondary school				Total
		Gymnasium/ Grammar schools	Civil engineering schools	Other technical schools	Other schools	
Female	N	18	9	7	5	39
		46.2%	23.1%	17.9%	12.8%	100.0%
		50.0%	24.3%	58.3%	33.3%	39.0%
Male	N	18	28	5	10	61
		29.5%	45.9%	8.2%	16.4%	100.0%
		50.0%	75.7%	41.7%	66.7%	61.0%
Total	N	36	37	12	15	100
		36.0%	37.0%	12.0%	15.0%	100.0%

Table 2. Candidates' secondary school GPA

Secondary schools	N	Min.	Max.	Range	Median	Mean	Std. Dev.
Gymnasiums/Grammar schools	36	28	50	22	41.91	41.22	6.278
Civil engineering schools	37	28	50	22	39.09	38.95	6.773
Other technical schools	12	27	49	22	39.68	38.97	5.806
Other schools	15	29	49	20	43.33	41.93	5.329
Total	100	27	50	23	40.89	40.22	6.322

Table 3. Attendance in mathematics preparation course and achievement in mathematics test.

Mathematics – preparation classes		Mathematics – pass score		Total
		Yes	No	
Yes	N	28	23	51
		54.9%	45.1%	100.0%
		65.1%	40.4%	51.0%
No	N	15	34	49
		30.6%	69.4%	100.0%
		34.9%	59.6%	49.0%
Total	N	43	57	100
		43.0%	57.0%	100.0%

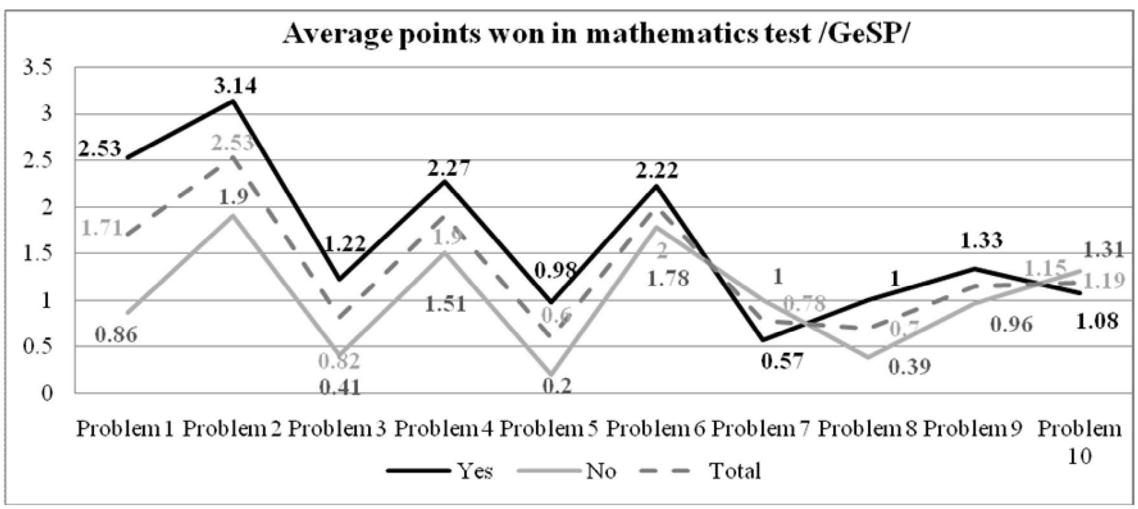

Figure 1. Average points won in mathematics test relative to attendance in preparation course (Geodesy Undergraduate Course).