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ПОРЕЂЕЊЕ УСПЈЕХА СТУДЕНАТА ИНЖЕЊЕРСТВА ИЗ ПРЕДМЕТА НАЦРТНА ГЕОМЕТРИЈА У ЗАВИСНОСТИ ОД ПРОФИЛА СТУДИЈА

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Резиме:

Нацртна геометрија је један од фундаменталних предмета у образовању будућих инжењера архитектуре, грађевинарства и геодезије. Током извођења наставе на овом предмету уочене су одређене разлике у брзини савладавања градива, као и у успјешности студената у односу на профил струке. Да би се прецизније установиле уочене разлике у савладавању градива анализиран је и поређен успјех студената различитих студијских програма АГГФ-а на првом и другом колоквијуму и завршном испиту, разлике у успјеху по профилу студија, као и утицај (корелација) пријемног испита и успјеха у средњој школи на коначан успјех из овог предмета. Посебна пажња је посвећена анализи постигнутих резултата студената архитектуре на тесту перцепције и презентације простора како би се утврдило да ли студенти архитектуре постижу бољи успјех, с обзиром да су кроз припрему за пријемни испит прошли одређени тренинг просторних способности.

Кључне ријечи: нацртна геометрија, пријемни испит, инжењерске студије

COMPARISON OF PERFORMANCE OF ENGINEERING STUDENTS IN DESCRIPTIVE GEOMETRY IN RELATION TO THEIR STUDY PROGRAM

Abstract:

Descriptive geometry is one of the fundamental subjects in the education of future architects, civil engineers and engineers of geodesy. During the course, certain differences in mastering the teaching material have been noticed, as well as the divergence in performance of students in relation to their study program. In order to analyse these differences more closely, we made comparison of the students achievements at the first and second colloquium and final exam, analyzed the differences in relation to the study program, as well as the impact (correlation) of the entrance exam and the success in the secondary school on the final results in the course. Special attention was paid to the analysis of the results of the architecture students in the spatial ability test in order to determine whether the students of the architecture have more success in the subject of Descriptive geometry, considering that they have undergone certain training of spatial abilities through their preparation for the entrance exam.

Key words: descriptive geometry, entrance exam, engineering studies

1.

2. INTRODUCTION

Descriptive geometry is a course in the first year at the Faculty of Architecture, Civil Engineering and Geodesy in Banja Luka. At most other universities in the region, this course is also obligatory in the first year of the above-mentioned study programs.

At the departments of Civil Engineering and Geodesy, this course covers following topics: general elements of projecting; point, line, plane and their mutual relations; transformation, rotation, intersections of straight lines; intersections of planar surfaces and solids both in isometric and orthogonal projection; roofs and terrain leveling. At the department of Architecture, this content corresponds to the course of Visualization and Modeling 1, with the exception of terrain leveling considering the different amount of teaching hours. Students of the department of Civil Engineering and Geodesy study this course in the first semester attending 6 hours/week (2 hours of lectures + 4 hours of theoretical assignments), and students of architecture attend this course in the second semester with attending 4 hours/week (2+2) in total.

The aim of the course is to gain a better perception of three-dimensional space and its graphic representation at the level of the drawing, to understand the graphical transformation and deformation of spatial elements used in Architecture, Civil Engineering and Geodesy as well as to learn various graphical methods for their presentation. The course provides candidates with spatial-geometric knowledge necessary to solve geometric problems in further education and engineering practice.

During the course, certain differences in mastering the teaching material have been noticed, as well as the divergence in performance of students in relation to the study program they enrolled, although the structure of students (origin, age, education) at these departments is homogeneous and uniform. The aim of this paper is to try to determine whether these differences exist and what is the possible cause for this.

Certain percentage of students has already been acquainted with the concept of space or some kind of spatial geometry before they enrolled the University. Students who enrolled the Faculty of Architecture, Civil Engineering and Geodesy come from different high schools and cities. Some of them already attended the subject of Descriptive geometry in high school, and some did not, so it was necessary to start the course with the basic elements of space: point, line and plane.

Exceptionally, students of Architecture were familiarized with spatial geometry earlier, at the entrance exam for the Faculty. In addition to mathematics, freehand drawing and general knowledge test, they had to take the test of spatial perception and presentation, where candidates were expected to demonstrate the ability to mentally manipulate elements in space by noticing proportion, perspective, parallelism and symmetry. Students of Civil Engineering and Geodesy take the entrance exam exclusively in mathematics and physics.

3. RESEARCH AND METHODOLOGY

3.1. AIM OF THIS RESEARCH

In order to determine the observed differences in the mastering of the teaching materials more precisely, we made comparison of the students achievements at the first and second colloquium and final exam, analyzed the differences in relation to the study program, as well as the impact (correlation) of the entrance exam and the success in the secondary school on the final results in the course. Special attention was paid to the analysis of the results of the architecture students in the spatial ability test in order to determine whether the students of the architecture have more success in the subject of Descriptive geometry, considering that they have undergone certain training of spatial abilities through their preparation for the entrance exam.

The test of spatial ability contains a series of tasks that estimate the ability of mental rotation (Fig. 1), the surface development (Fig. 2), the mental cutting (Fig. 3) or other spatial abilities [3, 4]. This test evaluates the innate perceptual abilities of the candidate, but some experience in solving these types of tasks could increase spatial skills. To prepare for the test students used Annual bulletin for prospective students published by the Faculty containing a collection of tasks from previous admission exams with correct answers attached [8].

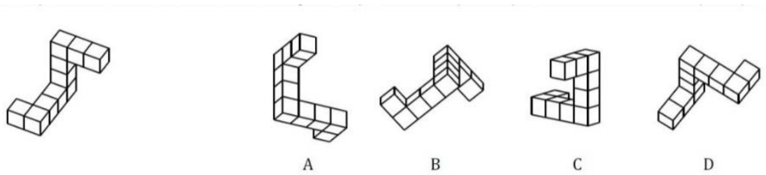

Figure 1. Mental rotation test (Respondents should determine which of the rotated figures offered on the right matches the given object on the left)

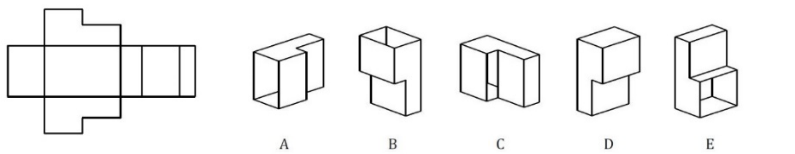

Figure 2. Surface development test (Respondents should determine which of the solids offered on the right matches the unfolded object given on the left)

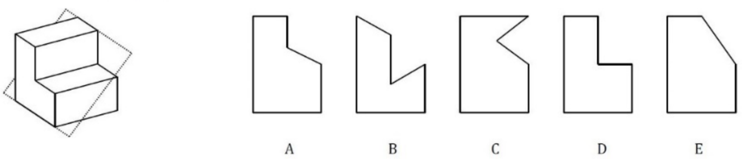

Figure 3. Mental cutting test (Respondents should determine which of the sections given on the right matches the figure on the left cut with the given plane)

The goal is to determine whether the entrance exam to the study program of architecture, due to the spatial test preparation, influences understanding and mastering the subject of Descriptive geometry later during the study, and whether the difference in the amount of teaching hours spent affects student's performance between the study program. Also, it is assumed that students of architecture, by the nature of the study, have a better perception of space. But is that really the case here?

3.2. RESEARCH STRUCTURE AND METHODOLOGY

A total of 223 first-year students during the two academic years (2015/2016 and 2016/2017) were included in this research. Students that took the course of Descriptive geometry for the second time or more were not covered by this research.

Table 1. Number of students by study program

	Number	Percentage
Civil Engineering	65	29.0%
Geodesy	68	30.8%
Architecture	90	40.2%
Total	223	100.0%

For the analysis of the results we used the analytical-statistical software package SPSS v.20 using descriptive statistics for presenting and summarizing data, the nonparametric Kruskal -Wallis test and Mann-Whitney U test, Spearman's rank correlation coefficient [6].

4. RESULTS AND DISSCUSION

Table 2. Avarage results on high school and entrance exam performance of all students

	N	Minimum	Maximum	Mean	Std. Deviation	Median
High school performance	221	27.87	50.00	40.57	5.43	40.71
Entrance exam performance	221	15.00	50.00	25.20	8.53	23.00

Table 3. Avarage results on high school and entrance exam performance by study program

	Study program	N	Minimum	Maximum	Mean	Std. Deviation	Median
High school performance	Civil Engineering	63	27.87	50.00	40.28	5.60	40.43
	Geodesy	68	27.89	50.00	40.27	5.65	40.64
	Architecture	90	30.21	50.00	40.99	5.16	40.74
Entrance exam performance	Civil Engineering	63	15.00	46.00	24.78	9.01	23.00
	Geodesy	68	15.00	50.00	26.71	10.38	24.50
	Architecture	90	15.00	42.00	24.34	6.21	23.00

At the entrance exam, out of a 100 credits in total, 50 credits could be scored with average grades from high school, while the other 50 candidates score at the exam. It is evident from Table 2 and 3 that the average result in the entrance exam (25.20) does not correspond to the average grade in the high school (40.57), which indicates that their level of applicable knowledge from high school is not appropriate. Students of Geodesy have slightly better secondary school performance compared to the other two study programs.

Table 4. Results on colloquiums in DG

	Study program	N	Minimum	Maximum	Mean	Std. Deviation	Median
Colloquium 1 (passed)	Civil Engineering	36	10.50	20.00	14.88	3.54	13.75
	Geodesy	22	10.50	19.00	15.23	2.70	16.25
	Architecture	33	10.50	19.50	13.46	2.47	13.00
Colloquium 2 (passed)	Civil Engineering	40	10.50	20.00	15.86	3.67	16.75
	Geodesy	43	10.50	20.00	14.36	3.47	14.00
	Architecture	43	10.50	20.00	13.51	3.31	12.00

Each colloquium gets 20 points maximum. To pass colloquium, student must score 51%. For the final grade, points from colloquiums are added only if the colloquium is passed.

Table 4 shows that more students show better success at the second colloquium, a total of 126 students (56.5%) passed, while the first colloquium passed 91 students (40.81%).

In comparison of the first colloquium results between study programs, there is no statistically significant difference in success (Kruskal -Wallis test $\chi 2 = 5.586$, df = 2, p = 0.61), while the second colloquium showed a statistically significant difference in success Kruskal -Wallis test $\chi 2 = 10.025$, df = 2, p = 0.007) (Table 4). Additional Mann-Whitney test showed the difference between students of Civil Engineering (Md = 16.75, N = 40, tab.4) and Architecture (Md = 12.00, N = 43, tab.4) (U = 518.500, z = -3.140, p = 0.002). Students of Civil Engineering have shown better performance than students of Architecture.

Table 5. Results on both colloquium

Study progeram	N	Minimum	Maximum	Mean	Std. Deviation	Median
Civil Engineering	28	21.00	40.00	31.38	6.27	30.50
Geodesy	17	24.50	38.00	31.32	4.90	32.00
Architecture	23	21.00	36.00	29.32	4.04	30.00
Total	68	21.00	40.00	30.67	5.28	30.50

Table 5 shows the number of students who passed both colloquiums 68 (30.5%) in total. It is noticed that students of Civil Engineering have shown better performance on both colloquiums (43.08%), while only 25% of students of Geodesy and 25.5% of students of Architecture passed both colloquiums.

Table 6. Final exam results

	група	N	Minimum	Maximum	Mean	Std. Deviation	Median
Final exam	Civil Engineering	46	22	49	33.82	6.25	33.50
	Geodesy	41	24	50	33.01	6.34	32.00
	Architecture	62	26	50	38.42	7.50	36.00
	Total	149	22	50	35.51	7.22	34.00

The final exam carries a total of 50 points and consists of a written (40) and oral test (10). The oral part of the exam is not required.

The Kruskal-Wallis test did not show a statistically significant difference between groups at the final exam ($\chi 2 = 5.216$, df = 2, p = 0.074).

If we observe only those students who passed the final exam, the Kruskal-Wallis test showed a statistically significant difference between the study programs at the final exam ($\chi 2 = 15.937$, df = 2, p = 0.000). Using the Mann-Whitney test, this difference, at a significance level of 0.05, was discovered between the students of Geodesy (Md = 32.00, N = 41, tab.6) and the Architecture (Md = 36.00, N = 62, tab.6) (U=2249.00, z = -2.198, p = 0.028). Students of Architecture have shown better performance at the final exam compared to students of Geodesy.

Table 7. Final scores in Descriptive geometry

	група	N	Minimum	Maximum	Mean	Std. Deviation	Median
Total score (final exam + colloquium + theoretical assignments score)	Civil Engineering	45	51.40	96.60	66.79	13.64	65.24
	Geodesy	39	51.10	94.74	63.59	12.94	61.40
	Architecture	62	51.00	94.20	61.75	12.72	54.80
	Total	149	22	50	35.51	7.22	34.00

The final grade is the sum of the points earned on the class (through theoretical assignments) - maximum of 10 points, colloquiums - maximum of 40 points, and the final exam - maximum of 50 points.

Using the Kruskal-Wallis test, a statistically significant difference was found in the final scores among the students who passed the exam ($\chi 2 = 6.902$, df = 2, p = 0.032). Using Mann-Whitney test, this difference was discovered at the significance level of 0.05 between students of Civil Engineering (Md = 65.24, N = 45, tab.7) and Architecture (Md = 54.80, N = 62, tab.7) (U=989.500, z = -2.561, p = 0.010). Students of Civil Engineering have achieved a better final scores.

The positive median correlation between the performance on the first colloquium and the performance on the final exam was shown (Spearman's rank correlation coefficient is 0.341 at a significance level of 0.01), as well as between the success at the second colloquium and the success at the final exam (Spearman's rank correlation coefficient is 0.374 level of significance 0.01).

Observing the final scores (the total sum of points) from the Descriptive geometry, there is a positive correlation between grades in secondary school and final scores (Spearman's rank correlation coefficient is 0.425, at significance level of 0.01) and between the final scores and the performance at the entrance exam (Spearman's rank correlation coefficient is 0.243, at the significance level 0.01).

Table 8. Results on spatial ability test

Study program	N	Minimum	Maximum	Mean	Std. Deviation	Median
Architecture	90	2.00	17.50	9.39	3.98	9.00

The positive median correlation between the results on the spatial ability test and the final scores in Descriptive geometry was found for the students of the Architecture who passed the subject (Spearman's rank correlation coefficient is 0.389, at the significance level of 0.01).

5. CONCLUSION

Based on the obtained results, we see that 69.32% of students enrolled in the Civil Engineering study program, 57.35% of the students of the Geodesy and 68.89% of the students of Architecture have passed the subject of Descriptive Geometry in the current academic year.

By comparing colloquium results, a statistically significant difference in performance between students of different study programs was discovered at the second colloquium, where students of the Civil Engineering showed better performance than students of Architecture. Thus, they are more successful in understanding spatial relations and intersections of geometric solids (both two-dimensional and three-dimensional projections).

Also, most students of the Civil Engineering have passed both colloquiums (43.08%), and only 25% of students of Geodesy and Architecture did the same.

However, at the final exam, students of Architecture have shown better performance than students of Geodesy. It should be noted that the test on the final exam in the study program of Architecture slightly differs from the final test on the other two study program. At the final exam, students of Civil Engineering and Geodesy are tested on drawing methods of solids in orthogonal projections, their intersections with planes and terrain leveling, while students of Architecture are also tested on drawing methods of solids in isometric and orthogonal projections and roofing tasks.

For the final grade in the Descriptive geometry, all points scored during the pre-examination and exam activities are summed. So when we analyzed and compared the overall success of students of different study programs who passed the exam, we came to the conclusion that students of Civil Engineering showed generally better performance than students of Architecture and Geodesy.

Positive correlations between scores on colloquiums and the final exam, as well as between performance in secondary school and final scores, and scores on the entrance examination and final grades, have also been obtained.

A positive median correlation between performance on the spatial ability test on the entrance exam and the final scores in Descriptive Geometry for the students of the Architecture who passed the exam was obtained.

From all of the above, it can be concluded that the students of Civil Engineering are the most successful in understanding and mastering the course of Descriptive geometry, although they do not take the spatial ability test on the entrance exam. The performance in secondary school has proved to be significant; a middle, almost positive correlation between performance in high school and final scores in DG (r_S = 0.425) has been obtained, while somewhat lower, but still, a positive correlation between the results on the entrance exam and final scores (r_S = 0.243). However, one should bear in mind the fact that students of Civil Engineering and Geodesy are taking this course with a total amount of 6 hours/week, while students of Architecture take 4hours/week, with a somewhat reduced amount of teaching material.

In earlier research it was concluded that the introduction of some graphic software in teaching Descriptive geometry could contribute to easier mastering and understanding of this course [1, 7]. Also, there are some dynamic graphic animations as well as video tutorials published on the internet site of the course [9] that students can use. However, it has also been shown that students rarely use this type of didactic material [1], but those who had used it, showed better performance on the exams. It has been shown that even those who have had this subject in high school do not show a better performance at final exam compared to students who did not have Descriptive geometry in high school [2]. And the results of previous research have shown also that students of Civil Engineering are more successful in mastering and understanding the subject of Descriptive geometry [1].

Finally, we can conclude that students of Civil Engineering are more successful than students of Geodesy and Architecture in understanding geometric problems in three-dimensional space and presenting these problems in a two-dimensional plane.

The performance in high school, as well as the results on the entrance exam, is in a positive correlation with the final performance in this subject.

We believe that the difference in the amount of teaching hours could be the reason for the weaker performance of the students of Architecture, and that the intended number of hours spent in the class is insufficient to overcome the planned program of the course, bearing in mind the fact that students work and learn mostly during the class.

LITERATURE

[1] S. Kosić-Jeremić, M. Ilić, D. Tepić, "Nastava Nacrtne geometrije i tehničkog crtanja na tehničkim fakultetima-primjer Arhitektonsko-građevinsko-geodetskog fakulteta u Banjoj Luci", u Zbornik radova sa 5. Naučno-stručnog skupa sa međunardnim učešćem Tehnološke inovacije - generator privrednog razvoja, novembar, 2016, pp. 157-168

[2] D. Tepić, S. Kosić-Jeremić, M. Ilić, "Eksterni uticajni faktori u savladavanju gradiva iz Nacrtne geometrije kod studenata arhitekture", AGG+ časopis za arhitekturu, građevinarstvo, geodeziju i srodne naučne oblasti, vol.4 (1), pp. 22-33, 2016.

[3] M. Ilić and A. Đukić, „Typology of spatial ability tests and its implementation in architectural study entrance exams“, Facta Universitatis, Series: Architecture and Civil Engineering, pp. 001-014, 2017.
[4] Z. Juscakova and R. A. Gorska, "TPS Test Development and Application into Research on Spatial Abilities," Journal for Geometry and Graphics, vol. 11, no. 2, pp. 223-236, 2007.
[5] Lj. Preradović and S. Kosić-Jeremić, "Student achievement in the university entrance examination and the effects of preparation classes – a case study of civil engineering students", Tehnički vjesnik/Technical Gazette, vol. 22, no. 3 , pp. 785-791, 2015.
[6] Lj. Preradović and V. Đajić, Analitičko-statističke tehnike u savremenim istraživanjima, Arhitektonsko-građevinski fakultet, Banja Luka, 2011.
[7] A. Talić-Čikmiš and D, Spahić, "Nacrtna geometrija na savremenom studiju tehnike", 8. Naučno-stručni skup sa međunarodnim učešćem, KVALITET 2013, Neum B i H, juni, 2013.
[8] http://aggf.unibl.org/sr/vesti/2017/02/informator-za-skolsku-20172018-godinu
[9] http://aggf.unibl.org/sr/studijski-programi/studije-prvog-ciklusa/gradjevinarstvo/predmeti/ngtc