Operations Research and Engineering Letters
Vol. 3, No. 1, 2024, pp. 1-7
ISSN: 2812-9318

Predictors of Academic Success of Geodesy Students

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Article Info

Article history:

Received December 18, 2023
Revised January 10, 2024
Accepted January 27, 2024

Keywords:

Predictors;
Decision tree;
Study success.

ABSTRACT

The paper presents and analyzes the factors that affect the enrollment and completion of studies of candidates in the Geodesy study program at the Faculty of Architecture, Civil Engineering and Geodesy of the University of Banja Luka, who were enrolled in the first admission period in the period 2012 to 2015. The influence of mathematics subjects on the completion of studies was analyzed in particular. With advanced techniques for data analysis, generation of decision trees and related rules, using data mining methods, it was shown that passing at least one mathematics course in the current academic year is an important predictor for the completion of studies.

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1. Introduction

In the first year of studies of the first cycle, the mathematical subjects are: Linear Algebra and Analytical Geometry (LA&AG), Differential and Integral Calculus 1 (DIC1) and Differential and Integral Calculus 2 (DIC2). Most of the candidates who enroll in the Geodesy Study Program at the Faculty of Architecture, Civil Engineering and Geodesy of the University of Banja Luka come from construction schools and high schools, and better results on the entrance exam are achieved by students who have completed high school (Preradović & Kosić-Jeremić, 2015). The importance of the entrance exam for admission to the Faculty of Architecture, Civil Engineering and Geodesy (FACEG), as well as the connection between success on the entrance exam and success in taking mathematics courses was analyzed in the paper (Preradović & Kosić-Jeremić, 2019), while the influence of taking mathematics courses in predicting the academic success of students analyzed in works (Preradović et al., 2021), (Preradović et al., 2022), (Preradović et al., 2014), (Preradović & Stojisavljević, 2023).

Three factors that determine a candidate's enrollment in the course were analyzed: success in high school, the result of the qualifying exam, the total number of points earned; and then passing mathematics subjects during studies; the status of enrolled students and the completion of the first cycle studies, as well as the connection between taking certain courses and graduating. By additional application of more advanced techniques (Data mining), the prediction of the distribution of students was improved.

2. Research Organization

During the first enrollment term in 2012, 2013, 2014 and 2015. 158 students were enrolled in the Study Program (SP) of Geodesy.

Both high school success and the qualifying exam are valued with 50 points each, and a minimum of 15 points is required to pass the qualifying exam. The entrance exam is taken in mathematics. Until the beginning of the 2023/24 school year. year 91 students graduated (completed the study of the first cycle), four students are still active (but did not graduate), 10 students transferred to another higher education institution, and 31 students enrolled, while 22 students are inactive.

Analytical and statistical tool IBM SPSS Statistics, version 27 (Preradović et al., 2014), (Preradović & Stojisavljević, 2023) was used in the analysis and graphical presentation of data, application of adequate statistical tests (Kruskal Wallis and Mann-Whitney U test) and classification trees. Data mining methods and classification trees, which represent the most commonly used statistical techniques in the field of generating rules from data, were additionally used to improve the prediction of student division (Preradović & Đajić, 2011), (Jakšić & Maksimović, 2011), (Rokach & Maimon, 2015), (Quinlan, 1986).

3. Research Results

During high school education, the candidates achieved solid success (the median was from 37.5 /2013 to 44.66 /2014), while during the entrance exam they achieved worse results (the median was from 24 /2012 / until 32.5 /2013/). The total number of points obtained by the candidates varied (the median was: 67.385, 70.415, 69.375 and 67.47, respectively, in relation to the years of enrollment) - Figure 1.

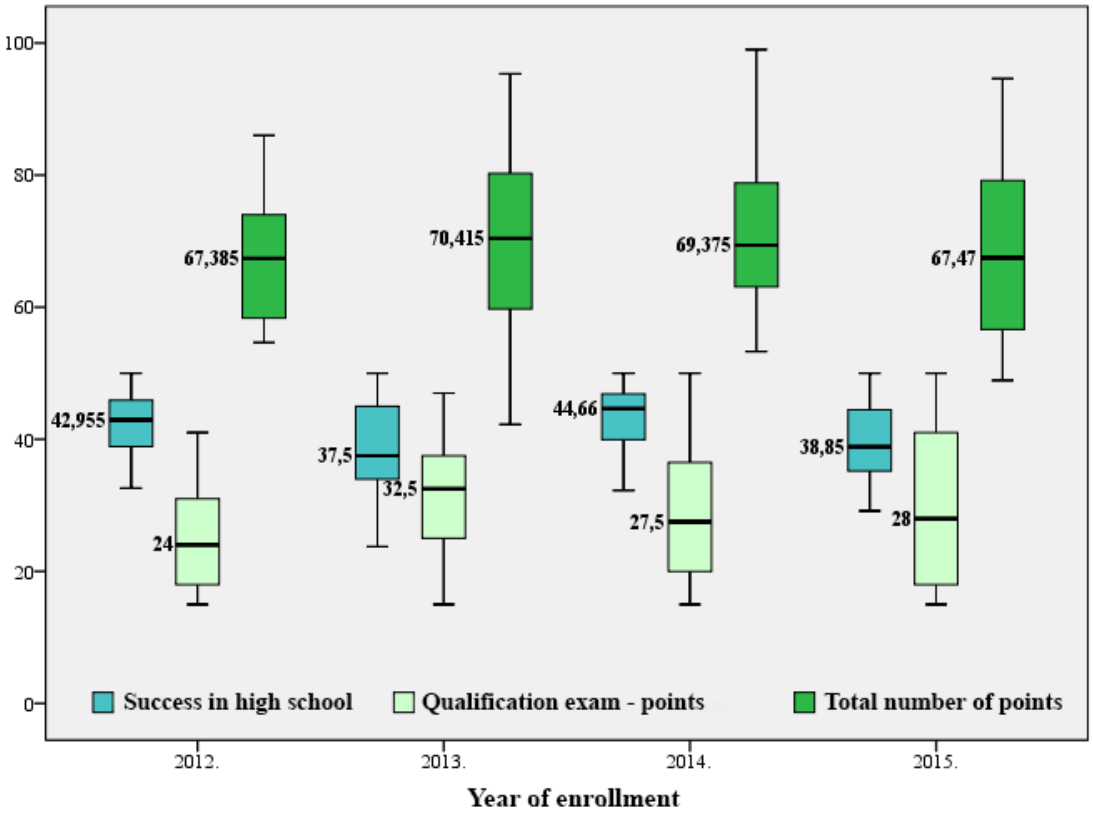

Figure 1. Success in high school, points on the qualifying exam and the total number of points

Applying the Kruskal-Wallis test, a highly statistically significant difference was obtained in the candidates' points obtained during secondary education (χ^2 = 13.456, p = .004), and a statistically significant difference during the entrance exam (χ^2 = 9.668, p = .022) , while there was no statistically significant difference in the total points scored (χ^2 = 2.890, p = .409) of the candidates in relation to the years of the entrance exams.

By testing each other's results that the candidates achieved by comparing two school years, applying the Mann-Whitney test:

- **candidate's success during high school education**: a highly statistically significant difference (z = -2.888, p = .004) was obtained between candidates who graduated from high school in 2013 and 2014. and candidates who graduated from high school in 2014 and 2015. (z = -2.743, p = .006), and a statistically significant difference (z = -2.1406, p = .016) of candidates who graduated from high school in 2012 and 2013;
- **entrance exam**: a highly statistically significant difference (z = -3.378, p = .001) was obtained between candidates who graduated from high school in 2012 and 2013. (table 1).

Table 1. Statistical significance of the results achieved during high school education and the entrance exam

School year	Success in high school	Entrance exam
2012. and 2013.	z = -2,406, p = ,016*	z = -3,378, p = ,001**
2012. and 2014.	z = -1,100, p = ,271	z = -1,627, p = ,107
2012. and 2015.	z = -1,855, p = ,064	z = -1,438, p = ,150
2013. and 2014.	z = -2,888, p = ,004**	z = -1,521, p = ,128
2013. and 2015.	z = -,734, p = ,463	z = -,995, p = ,320
2014. and 2015.	z = -2,743, p = ,006**	z = -,056, p = ,955

Analyzing active students, 23 (92%) students enrolled in 2012, 33 (100%) enrolled in 2013, 19 (100%) enrolled in 2014 and 16 (88.89%) enrolled in 2015 completed their first cycle studies. (table 2).

Table 2. Completion of first cycle studies

Graduated	Year of enrollment				Total
	2012.	2013.	2014.	2015.	
Yes	23	33	19	16	91
No	2	0	0	2	4
Total	25	33	19	18	95

The average duration of studies of students who graduated was 2131, 2019, 1920 and 1968 days, respectively according to the years of enrollment. Testing, using the Kruskal-Wallis test, the duration of study (days) does not differ statistically significantly ($\chi^2 = 3.304$, p = 0.347) in relation to the school year of enrollment.

In the current school year, 85 students passed the LA&AG course, of which 79 (92.94%) graduated; subject DIC1 was passed by 81 of whom 76 (93.83%) graduated; and the course DIC2 was passed by 38 of whom 37 (97.39%) graduated. During the next school year, 14 passed the LA&AG course, of which 11 (78.57%) graduated; subject DIC1 was passed by 15 of whom 10 (66.67%) graduated; and the subject DIC2 was passed by 32 of whom 31 (96.88%) graduated. After two school years, four passed the LA&AG subject, one of whom (25%) graduated; subject DIC1 was passed by seven of whom five (66.67%) graduated, and subject DIC2 was passed by 31 of whom 23 (74.19%) graduated.

By monitoring the connection between passing two or all three mathematical subjects that students study during the first year of study, the results show that students successfully complete their studies if they pass at least two subjects during the current year or at least one during the current year, and the second or both the second and third subjects during the next or after two years (table 3).

Table 3. Correlation between taking individual courses and graduation

Subject(s)	Passed in the current year	Graduated	Passed in the next year	Graduated	Passed after two years	Graduated
LA&AG	85	79 (92,94%)	14	11 (78,57%)	4	1 (25%)
DIC1	81	76 (93,83%)	15	10 (66,67%)	7	5 (71,43%)
DIC2	38	37 (97,39%)	32	31 (96,88%)	31	23 (74,19%)
LA&AG and DIC1	73	73	21*	13	7**	5
LAiAG and DIC2	37	37	33*	31	31**	23
DIC1 and DIC2	38	37	32*	31	31**	23
LA&AG, DIC1 and DIC2	37	37	31*	31	23**	23

* at least one of the subjects was passed in the following year

** at least one of the subjects was passed after two years

Additional improvement in the prediction of student graduation success is achieved by applying advanced techniques (eg data mining). As an example, a simple classification tree is presented in Figure 2.

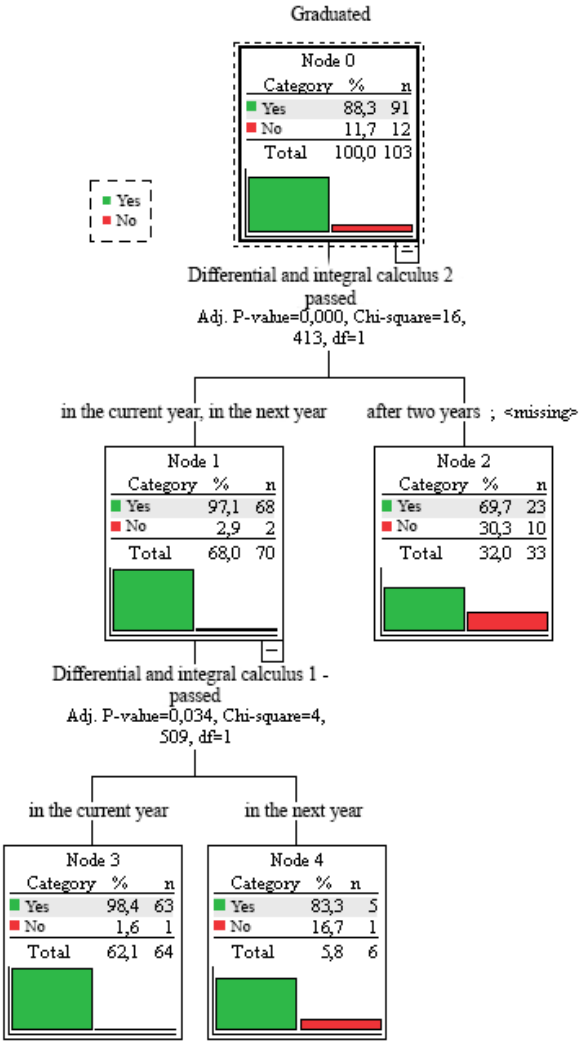

Figure 2. Example of a classification tree

The generated rule for the third node is listed as an example:

/* Node 3 */.
IF (Differential and integral calculus 2 - passed = "in the current year" OR Differential and integral calculus 2 - passed = "in the next year") AND (Differential and integral calculus 1 – passed != "in the next year")
THEN
Node = 3
Prediction = 1
Probability = 0.984375

It can be seen that 63 out of 64 students who passed the subject Differential and integral calculus 2 during the current OR next school year and who passed the subject Differential and integral calculus 1 during the current year and graduated.

When forming certain variables, it is possible to obtain interesting rules. Table 4 presents five simple rules when forcing the variables success in high school or points earned during the qualifying exam or total points earned.

Table 4. Examples of generated rules by forcing individual variables

Forced variable		Probability of graduation
Name	Value	
Success in high school	> 45	1
Entrance exam - points	> 39	1
Total number of points	> 73,33	1
Total number of points	≤ 56,48	0,5
Total number of points	(56,48 - 73,33)	0,865

4. Discussion

Higher education institutions carry out many activities in order to select the best possible candidates for further education. The selection of candidates for enrollment is very complex and requires intensive work with potential candidates during secondary school education. Since 2012. researches regarding the passing of entrance exams at the FACEG began (Preradović et al., 2014). For 10 years, FACEG has been conducting workshops in high schools where construction professionals are trained and in high schools and conducting preparatory classes. Preparatory classes are conducted over 20 hours (five weeks) online, through Google Meet and Google Classroom applications (FACEG, 2023). The importance of preparatory classes is also recognized by local faculties that organize preparatory classes and/or enable candidates to use solved tasks from the entrance exam in mathematics (FACEG, 2023), (Faculty of Civil Engineering, 2023, 2023a), (Faculty of Civil Engineering Subotica, 2023, 2023a), (GAF, 2023, 2023a), (Faculty of Technical Sciences, 2023a). The criteria for admission to undergraduate university studies in Croatia are based on: high school success (400 points) and passing exams at the state matriculation exam (Croatian language - 50, mathematics up to 450 and physics (not a requirement for enrollment, but brings points/ up to 100 points); based on achievements in competitions - direct enrollment (1000 points) /participation in state competitions in mathematics and physics or winning one of the first three places in construction technology/ (Faculty of Civil Engineering, 2021).

Some faculties, even after enrollment, organize the preparation of candidates (students) for a future call even before the start of classes (Faculty of Technical Sciences, 2023).

After a good selection of candidates for enrollment, it is necessary to investigate the impact of passing certain exams, already during the first year of study, on the success of completing the studies. To predict the results, it is necessary to use more advanced techniques. The paper (Simeunovic & Preradović, 2014) describes the creation of a model for predicting the success of students during their studies using data mining and analyzing the factors that influence the degree of success achieved. Three data mining methods were examined: logistic regression, decision tree and neural networks. The study (Alyahyan & Düştegör, 2020) aims to provide a step-by-step set of guidelines for teachers who are ready to apply data mining techniques to predict student achievement. Kehinde et al. (2021) point to the potential of artificial neural networks where, using multi-layer neural networks without feedback, based on students' demographic data, they successfully create a model that predicts the final outcome of students with an accuracy of 92%. The paper (Šimić & Gusić, 2020) analyzed data on the success of studying and passing exams in the first year of undergraduate

studies for eight generations of students. The goals of the research were: to create a predictive model that will enable the identification of students who are highly likely not to achieve 30 ECTS points during the academic year and to provide students with information on the probability of passing a particular exam, i.e. achieving the target number of ECTS points at the end of the academic year. A Bayesian network was used to model the pooled distribution.

5. Conclusion

Candidates achieved solid success during secondary school education (over all years of enrollment, the average number of points was 41.15), while candidates achieved worse results during the entrance exam (average number of points was 28.53). The total number of points scored by the candidates was on average (for all candidates) 69.68.

Passing certain mathematics subjects during the current year of study indicates that the success rate of graduation prediction is from 92.94% to 97.39%.

By generating rules, further improvements and extensions of predictions can be obtained, as well as predictions based on the results achieved during high school education and during the qualifying exam.

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