

Exploring factors influencing students' success in a computer service course in Engineering Faculty of Atilim University: A discriminant analysis approach

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Abstract— The factors affecting the student success in programming course is long being studied subject, which keeps its importance in academia. With this study, the factors affecting the students' success in introductory programming course is being analyzed, based on the results obtained from 448 students records, who took CMPE102 course in second semester of 2015-2016 academic year. The independent factors include gender, department, taking prerequisite course, course repetition, and student's CGPA (Cumulative Grade Point Average) whereas the dependent one is the success in CMPE102. The discriminant analysis technique was utilized to represent the predictive discriminant model for the success of students, which is simply defined as taking DD grade. The chi-square test was also used whenever necessary. The results show that all factors in the model have significant discriminant effect on the success of students.

Keywords —*programming, success, gender, department, prerequisite, repetition, CGPA, discriminant.*

I. INTRODUCTION

Introductory level of programming skill is so important for non-major students that almost all engineering departments has at least one such compulsory course in their curriculum. This is because all engineering students need to use the programming knowledge heavily in their fields of study. It is generally accepted that learning how to program is a difficult task [1], even for computer/software major students. This makes it important for instructors to understand the factors affecting the students' success in such courses, so that they can help students to overcome the challenges in their learning progress.

There are studies in the literature analyzing different factors affecting the student success of learning to program in the literature [1, 3, 4, 6, 10, 11, 13, 21, 22]. However, almost all of these studies investigate the degree and type of relationships between academic success and factors of interest. They generally consider the success as Cumulative Grade Point Average and the data are collected

from different levels of education system changing from primary schools to universities. Additionally, these studies do not pay much attention to diversities of background of students from different disciplines, which are stated as important factors by researchers [2, 3]. On the other hand, it is also known that student success in first year courses has important influence on self-esteem and self-efficacy, which internally affects their success in subsequent years [4]. Therefore, the literature is not matured yet and there is a need to produce a predictive model.

Having said so, the present study aims to predict and explain the discriminant effect of selected factors on success of engineering students in an introductory computer programming course given by the Department of Computer Engineering Department of Atilim University. To the best of our knowledge discriminant modeling of academic success approach have not been used in the literature yet.

The results of the study can be utilized for the development, validation and evaluation of curriculum of engineering departments and course contents of introductory computer courses. It is equally important with the outcomes of such a model that students can be advised, motivated and tutored accordingly since motivation has positive effect on the success of learning to program. [5, 6]. In other words, student's success can be predicted at their registration to the course with this model at the beginning of the semester. Potential unsuccessful students can be given special tutoring in order to increase their success level.

The rest of the paper is organized as follows: Section 2 gives hypotheses and their backgrounds followed by research methodology explained in Section 3. Section 4 and 5 gives the descriptive and test results respectively, followed by conclusion section.

II. HYPOTHESES

The available literature provides studies on gender diversity regarding students' success for different levels of formal education. For example, Wilson, Brenda C. [22] reports that there is no significant difference between genders in terms of success in an elementary computer science course in college. Similarly, Goold and Rimmer [13] have reported a fluctuating influence of gender over semesters and across area of study. The outcomes suggest that gender has an impact on success only in the first programming unit, yet it has no effect on information technology area of study. On the contrary, Byrne and Lyons [11] points that, male students succeeded as equally as the females in a first year computer programming and logical methods course. De Winter and Dodou [12] also supported this view. According to their study, although higher average of high school exam scores was reported for females, gender was not found to be a significant predictive for first year GPA. As can be seen the literature is not conclusive for gender diversity and almost all of these studies investigate the degree and direction of relationships between factors but not consider the discrimination effect of gender on success. Therefore we postulate the following hypotheses.

H₁: Gender does not have a discriminant effect on the success of students in an introductory programming service course.

Cumulative Grade Point Average has been one of the main concerns of higher education in the last two decades. Benford and Gess-Newsome [4] reported that university grade point average of students is a more effective predictor variable than secondary school grade point average. Baxter, Hungerford, and Helms [9] stated that GPA of the students was a strong predictor variable of the students' success in the introduction to computers course. Similarly, Kiriakidis, Decosta, and Sandu [14] found a significant correlation between the grade point average of students and the final grades on courses taken face-to-face or online. Osborn [18] researched the impact of GPA on face-to-face and online learning and reported that the strength of GPA as a predictor has become prominent. All these may lead to the fact that CGPA may be an indicator of the success in a certain course. For this reason, we propose the following hypothesis.

H₂: Cumulative grade point average (CGPA) of the students does not have a discriminant effect on success of students in an introductory programming service course.

The literature provides evidences for the diversity in the success of students from different disciplines. For example, VanderStoep, Pintrich, and Fagerlin [19] explained that discipline-specific knowledge was important for academic performance. White and Llicardi [20] clarified the importance of disciplinary differences among

students in terms of refining the online learning design. A more recent study of Amoako, Sarpong, Arthur, and Adjetei [24] illustrated that field of study can be attributed to the performance of students in computer programming. Llicardi and White [15] also supported this view by stating e-learning methods changes based on the discipline. All these conclude that, in order to develop effective strategies for designing curriculums and course contents, there is a need to investigate the nature of differences between different disciplines and following hypothesis is proposed.

H₃: Departmental differences of the students do not have a discriminant effect on the success of students in an introductory programming service course.

There is quite large number of studies conducted on the effect of prerequisite courses on the success of a course that requires prerequisite course. However, findings are not conclusive. Barber, Weldon and Wysocki [8] reported the significance of a prerequisite course on the prediction of grades in senior-level marketing and finance courses. Weidenbeck, LaBelle, and Kain [21] have clearly reported the influence of previous programming experience on self-efficacy for programming. They concluded that self-efficacy of the students has an explicit impact on the comprehensive success in an elementary course. On the contrary, Abou-Sayf [7] highlighted the nonappearance of a significant difference between taking the course when the prerequisite course was offered as mandatory. Similarly, Wright, Cotner, and Winkel [23] revealed no significant difference on the average biochemistry grades between the students who took the organic chemistry as a prerequisite course and the ones who did not take. Bergin and Reilly [10] also supported this finding by stating no statistically significant difference between the success of students with or without prior programming experience or the students with or without a prior non-programming computer experience. There are obviously different perspectives and research results on the effect of a prerequisite course on the success of target course. This leads to the following hypothesis.

H₄: Taking a basic computer skills and programming course prior to taking an introductory programming course does not have a discriminant effect on the success of the introductory programming service course.

In order to determine the predictors of success in a course, researchers such as Morrison and Leong On No [16] have considered repeating a year as a factor to investigate its effect on the improvement or course performance. They concluded that repeating a year has either no significant difference or a negative impact on performance of students in the English course. Oppositely, Nasser and Nauffal [17] reported a significant difference between the students repeating a course at different frequencies. They also reported the negative impact of repeating a course more than once on the student's

performance. The literature is not matured in this respect and available literature mainly provides evidences on the relationships between student's academic success and taking a course more than once. They do not inspect discrimination effect of repeating a course.

H₅: Repeating an introductory programming service course does not have a discriminant effect on the success of the same course.

III. RESEARCH DESIGN

In this study, the data was collected from first year engineering students, who took the computer service course CMPE102 (Computer Programming) given by Computer Engineering Department of Atilim University during second semester of 2015-2016 academic year. The content of this course is "Programming concepts: data types, arithmetic expressions, assignment statements, input/output functions, library functions, selection and repetition statements, user-defined functions, arrays and strings". Except Manufacturing Engineering and Chemical Engineering and Applied Chemistry all the other departments include CMPE101 (Introduction to Computers and Programming) as a prerequisite of CMPE102 in their curriculum. The content of CMPE101 is given as "Basics of information systems, computer software, computer hardware: CPU, memory units, and I/O devices, Internet and networking, basic programming concepts, hands-on experience of application software and Internet through lab sessions" in the catalog of Computer Engineering department. There are 448 students in the data and collected data contains 6 variables. Success was taken as the dependent variable for the research. Gender, department type (Dept_Id), taking prerequisite CMPE101 (CMPE101_status), taking CMPE102 for the second time (CMPE102_status) and student's Cumulative Grade Point Average (CGPA) constitute independent variables in this research.

The discriminant analysis technique was utilized to represent the predictive discriminant model for the successful and unsuccessful students, where success was simply defined as "taking at least DD from the course". The chi-square test was used whenever necessary, especially for descriptive results.

IV. DESCRIPTIVE RESULTS

The descriptive results from the selected sample are given in Table 1.

The study is dominated by the male students since the percentage of the male students appears to be more (72.9%). Interestingly, departmental distribution of students was found significant (Chi-square = 65.445; DF = 10; p-value = 0.000) in terms of gender. A close inspection of data reveals that civil, electrical and electronics, and mechanical engineering departments are mostly preferred by male students since percentage of students in these

departments are 82.3%, 73.0% and 83.9% respectively. The female students show tendency to prefer Chemical Engineering and Applied Chemistry (72.4%), Metallurgical and Materials Engineering (40.6%), and Mathematics (66.7%) departments. Gender shows parallel dispersion in terms of academic success for both genders. In other words, of the male students, slightly more than half (56.9%) were found to be successful and this percentage is 58.7% for their female counterparts. Naturally, the distribution of gender versus success was not found to be significant (Chi-square = 0.117; DF = 1; p-value = 0.733).

Variable	Number	%
Gender	448	100
Male	327	72.9
Female	121	27.1
Cmpe101 Status	448	100
Took	400	89.2
Did Not Take	48	11.8
Cmpe102 Status	448	100
Taking for the First Time	298	66.5
Took More Than Once	150	34.5
Success	448	100
Not Successful	191	42.6
Successful	257	57.4
Department	448	100
Electrical and Electronics Engineering	63	14.1
Industry Engineering	32	7.1
Energy Systems Engineering	30	6.7
Manufacturing Engineering	19	4.2
Civil Engineering	124	27.7
Chemical Engineering and Applied Chemistry	29	6.5
Mechanical Engineering	56	12.5
Mathematics	6	1.3
Mechatronics Engineering	31	6.9
Metallurgical and Materials Engineering	32	7.1
Automotive Engineering	26	6.3
CGPA (as intervals)	448	100
3.5 - 4.0	10	2.2
3.0 - 3.5	19	4.2
2.5 - 3.0	25	5.6
2.0 - 2.5	75	16.7
1.5 - 2.0	117	26.1
1.0 - 1.5	103	23.0
0.5 - 1.0	56	12.5
0.0 - 0.5	25	5.5
Unknown	18	4.0

Table 1. Descriptive results

Chi-square test results do not show any significance for the distribution of success in CMPE102 versus departments (Chi-square = 11.571; DF = 10; p-value = 0.315). This is surprising because it is generally assumed that the students of the departments, which require higher scores in university entrance exam, are expected to be relatively more successful. Civil Engineering, Electrical and Electronics engineering, and Industrial Engineering are amongst these departments. More than 1/3 of the students (34.5%) in the analyses took CMPE102 for the second time due to failure in their first registration. Surprisingly, of these students 73.8% was observed to be unsuccessful. Additionally, taking this service course for the second or more time is significantly distributed against success status of the second time since test results were found as Chi-square = 86.897; DF = 1; p-value = 0.000. This means unsuccessful students continues to adopt their behavior towards unsuccessfulness.

The reader should note here that the prerequisite of CMPE102 is CMPE101 and some departments prefer not to include this prerequisite in their curriculum. There are 48 (11%) students in the data from those departments. Although the chi square analysis reveals that there is no significant dependence between the distributions of success in CMPE102 and taking CMPE101 as a prerequisite (Chi-square = 2.924; DF = 1; p-value = 0.087) one should be cautious on this result because the percent of students who did not take CMPE101 is as small as 11%.

V. TEST RESULTS

Collected data were analyzed to test the proposed hypotheses using discriminant analysis technique. First of all, it is important to note that discriminant tests show strong indication that the group covariances are significantly equal (Box's M=54.16; F: 3.564; p-val=0.000). Based on the canonical correlation, the test results also show significance for the prediction model since (Canonical correlation= 0.633; Wilk's lambda=0.599; Chi-square = 222.324; DF = 5; p-val=0.000). Group centroids were found as -0.969 and 0.686 for unsuccessful and successful students respectively. These conclude rejection of H1 - H5. This can be interpreted as CGPA, taking CMPE102 for the second time (CMPE102_status), Gender, taking CMPE101 as a prerequisite (CMPE101_status) and Department (Department_Id) all have significant discriminant effect on the academic success of students in the service course CMPE102. The results for the discriminant prediction model are given in Table 2. Inspection of this table reveals that highest positive discriminant effect comes from CGPA of students. This means freshman student's overall success in the first semester is a strong indication of success in CMPE102 taken in the second semester. Surprisingly, because the corresponding discriminant coefficient and unsuccessful group centroid are both negative and code for successful students is higher (unsuccessful=1;

successful=2), taking CMPE102 for the second time appears to be an indication of classifying the student as unsuccessful. This is probably because unsuccessful students do not show much responsible behavior when they take this course for the second time. This view is just opposite for taking or not taking CMPE101. This means taking CMPE101 as a prerequisite supports the students to be classified as successful. According to its discriminant coefficient (coeff. = -0.198) being female (male=1; female=2) is surprisingly an indication of potential of belonging to unsuccessful category. Interestingly, as also noted before, the weight of department is not as high as expected in the discriminant function since its coefficient was found as -0.004. Nevertheless, the departments like Electrical and Electronic Engineering (code=1), Industrial Engineering (code=2) and Energy Systems Engineering (code=3) students are more likely to be classified as successful.

Variables	Standardized Disc. Func. Coef.
CGPA	0.841
CMPE 102 Status	-0.452
Gender	-0.198
CMPE 101 Status	-0.135
Department	-0.004

Table 2. Prediction model

The results for predicted group memberships are given in Table 3. Inspection of this table shows misclassification to be as low as 19.5 for successful and 19.8 for unsuccessful students. Based on these percentages it is possible to conclude that a new student can be classified to correct success status group with 80% of probability at the beginning of the semester.

	Success Status	Predicted Group Membership		Total
		1	2	
Count	1*	146	36	182
	2*	50	207	257
%	1	80,2	19,8	100,0
	2	19,5	80,5	100,0

1* Not Successful 2* Successful

Table 3. Classification Results

VI. CONCLUSIONS

This research uses a systematic analysis approach to explore the factors affecting non-major engineering students' success in an introductory programming course given by Computer Engineering Department of Atılım University. Discriminant analysis technique was utilized and all the factors included in the analyses were found to

have significant discriminant effect on the success of students in the service course, which results in rejecting the hypothesis H1-H5 as explained in previous section.

The model produced shows misclassification rate to be as low as 20% on the average. This means, the model can be used to predict students' success at their registration to the course and potential unsuccessful students can be given special tutoring in order to increase their success level during the semester.

We propose to use larger samples including different service courses for further studies. This may lead to more insights on the factors influencing success of students. The analyses may be repeated using the data collected from different universities so that the effect of different university cultures and student profiles may possibly be investigated. Analyzing students from different disciplines of social sciences may also lead to interesting findings. Finally, effect of instructor's profile such as background, level of English, attitude is worth to investigate.

VII. REFERENCES

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