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Undergraduate programming courses, students' perception and success

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Abstract

Learning programming at university level is the challenge for both students and teachers, especially for students without previous exposure to programming. Most of the programming courses are compulsory and tough to learn for novice programmers. Students lack the understanding of basic programming concepts and algorithms and find programming difficult. Early failure of understanding important concepts weakens students' confidence and increases drop-out rate. Students' success rate and perception during most important programming courses at the undergraduate level at the Faculty of Science, University of Split over extended period of time were analyzed. Results of this research are presented in this paper.

Keywords: Novice programmers; undergraduate programming courses; learning and teaching programming

1. Introduction

Programming is challenging subject for learning and teaching. Introductory programming courses at the universities are very important since they are responsible for students' acquiring of basic programming skills and knowledge. Unfortunately, they also have highest drop-out rates and we also noticed that students do not have knowledge and skills as expected even after they pass introductory programming courses. It is important to note that introductory programming courses in the literature are often "hidden" under "Computer science" title (Pears et al., 2007) (Radenski, 2006) which makes literature research more difficult.

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Department of computer science at the Faculty of science (FOS), University of Split is responsible for teaching most of the programming courses for students with majors in computer science, mathematics, physics and technical science, with large number of students, especially in the introductory courses. It is not vast number of students compared to other universities in the world, but it is significant in the context of the faculty. In this paper, we examine students' success rate and perception during most important programming courses at the FOS.

In the next section we reflect on related work on programming difficulties for novice programmers and factors that might affect their learning of programming. Second section consists of data analysis and observations during three years on selected programming courses at the FOS.

2. Related work

According to some researchers, students mathematical abilities often positively reflect on their programming abilities (Bennedsen, 2008), (Sauter, 1986). Hence, teachers tend to design curriculum that favors such students, while other aspect such as problem solving might be neglected.

Expert programmers know more than novices, but researchers emphasize that the quantity of knowledge is not the only difference, because experts also organize their knowledge better (Lister, Simon, Thompson, Whalley, & Prasad, 2006). Novice programmers have a tendency of making context specific programs and demonstrate superficial knowledge of programming concepts (Lahtinen, Ala-Mutka, & Järvinen, 2005). They learn syntax and little pieces of code, but lack the ability to put all the pieces of the program together.

Researchers in (Hawi, 2010) emphasize ten factors that affected their students, and some of those factors that we also noticed through observation and interviews with our students were: "learning strategy", "lack of study", "lack of practice", "teaching method", "exam anxiety" and "cheating". Some of those factors were also noted in (Bennedsen, 2008) as predictors of success for programming. Students have additional difficulties with abstract thinking. In the research conducted by (Eckerdal, Thun, & Berglund, 2005), students were interviewed with the purpose of determining if they understood what learning programming means. Many students stated it is special way of thinking, but were not able to describe in detail.

In the next section, we analyze success rate for students at the FOS during three academic years in order to determine if there is correlation between introductory programming courses in first and second semester and introductory mathematical courses, and to examine success rate on following programming courses.

3. Undergraduate programming courses research

First year undergraduate students at the FOS have very few (if any) programming skills and knowledge. Some of those students enrolled major in computer science, and it is important to note that computer science study programme is for future school teachers of computer science. Knowing that, task for their teachers seems much more difficult since they have to teach adult novice programmers how to learn programming and also how to teach other novice programmers. Besides computer science majors, other students with major in physics, technical science and mathematics (or double major students with the combination of two subject) attend programming courses. That increases problems for teachers since different student groups (or student types) might require different approaches but curriculum is the same.

Each of two semesters at the FOS consists of 15 weeks. Most of the programming courses consist of two school hours (45 minutes) of lectures per week and two school hours of labs per week. During first semester, all students enroll introductory programming course Programming I (P1), and during second semester they enroll course Programming II (P2). During course P1 students learn procedural programming in Python as soft introduction to programming. Students find that course difficult since most of them learn programming for the first time. Second semester during P2 is still introductory, but P2 is "crossover" course between procedural programming and introductory object-oriented programming in C#. First half of P2 is sort of "crash course" in C# syntax with console applications and similar assignments and concepts covered in P1, then followed by second half of semester when students get introduced to graphical user interface.

3.1. Data collection and analysis

We collected data from all enrolled students during three academic years and most important (and challenging) programming courses at the FOS: Programming I, Programming II, Data structures and algorithms (DSA), Object oriented programming (OOP), Computer Architecture (CA), Databases (DB), Problem solving (PS) and Network Application Programming (NAP). Since we already stated that some researchers consider mathematical abilities very important in programming, we also analyzed information on two first mathematical courses: Mathematics I (M1) and Mathematics II (M2), during first and second semester, respectively. In Table 1 there is an overview of pass rate for selected courses. Total number of students contains total number of students that only enrolled course for the first time, for all three years combined.

Table 1. Pass rate for selected programming and mathematical courses

Course	2010/11	2011/12	2012/13	All three years	Total number of students
P1	60,87 %	53,67 %	48,47 %	53,62 %	511
P2	51,08 %	44,00 %	39,09 %	44,03 %	511
DSA	86,96 %	87,69 %	72,73 %	81,92 %	177
OOP	89,32 %	79,31 %	73,85 %	81,96 %	255
CA	77,50 %	75,00 %	64,15 %	73,06 %	193
DB	100,00 %	98,44 %	83,56 %	93,12 %	189
PS	84,78 %	58,33 %	75,86 %	78,16 %	87
NAP	95,12 %	82,61 %	80,65 %	86,44 %	118
M1	50,00 %	52,52 %	21,15 %	39,55 %	397
M2	42,16 %	39,57 %	16,03 %	30,98 %	397

It is obvious that success rate for programming courses P1 and P2 are the lowest, like mathematical courses M1 and M2. Since all those courses have the lowest pass rate among observed courses, interrelationship between final exam grades for those four courses was further analyzed using correlation analysis (Cohen, Manion & Morrison, 2007). Correlation analysis is used for measuring association between variables and there are several simple measures which depend on data type and distribution.

First step before correlation analysis is to check data distribution. There were some doubts about normality since graphical representation for each course and year diverted from normal curve (example for course M1 is on Fig. 1). Skewness coefficient was checked to determine if there is any further evidence that some variable is skewed.

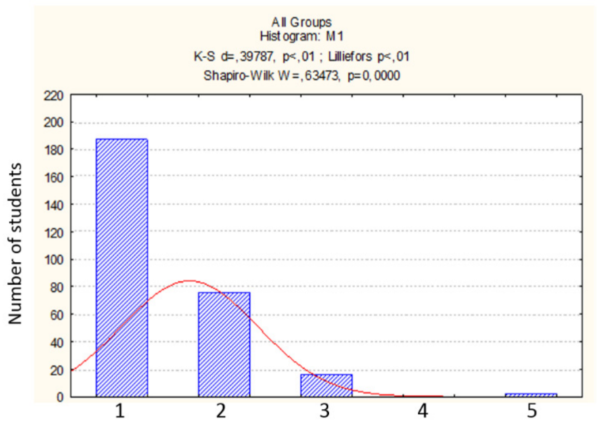
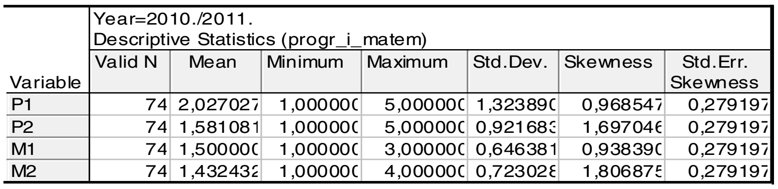


Fig. 1. Histogram for course M1 (grade distribution)

Simple check consists of examining that skewness coefficients are not too large: absolute values of the skewness coefficients should be less than two times their standard errors. Calculation for each course during each year demonstrated that data is not normally distributed (example for year 2010/11 in Fig. 2).



	Year=2010./2011. Descriptive Statistics (progr_i_matem)						
Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.	Skewness	Std.Err. Skewness
P1	74	2,027027	1,000000	5,000000	1,323890	0,968547	0,279197
P2	74	1,581081	1,000000	5,000000	0,921683	1,697046	0,279197
M1	74	1,500000	1,000000	3,000000	0,646381	0,938390	0,279197
M2	74	1,432432	1,000000	4,000000	0,723028	1,806875	0,279197

Fig. 2. Output analysis for year 2010./2011.

Hence data was not normally distributed, correlation analysis was conducted using Spearman's nonparametric test commonly used for ordinal data (Cohen, Manion & Morrison, 2007). Results are presented in Table 2.

Table 2. Spearman's correlation analysis

Variable	P1	P2	M1	M2
P1	1,000	0,802 *	0,655 *	0,626 *
P2	0,802 *	1,000	0,685 *	0,731 *
M1	0,655 *	0,685 *	1,000	0,747 *
M2	0,626 *	0,731 *	0,746 *	1,000

All correlations marked by asterisk are significant at the level p<0.05 which means there is significant correlation between all grades. Simple explanation might be demonstrated on example: most of the students who passed P1 also passed P2 (positive correlation 0.802). It would be wrong to assume that correlations imply causal relationships since success in one course does not cause success in other.

We stated that observed courses are considered most challenging but one might argue since pass rate for courses after first semester are much higher and that at first makes those courses seem less difficult. The fact is that students that failed course P1 were not able to enroll other programming courses besides course P2 which reduced the number of students in the following programming courses.

Students who enrolled courses more than once were also included in analysis since they participated in the survey and their expected and actual grades are presented in the Fig. 3. Since survey results were anonymous, it was not possible to compare expected grades with actual grades case by case.

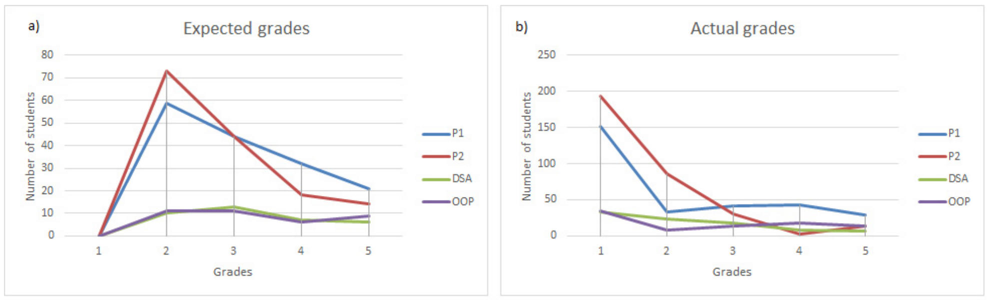


Fig. 3. (a) Expected grades (b) Actual grades

It was interesting that not a single student selected answer 1 (fail) in the survey, although there were many students who failed. The number of students who participated in the survey was much lower than actual number of students enrolled in each course. The survey was conducted once using pen and paper forms with students who were present in the lab that particular day. Some of the enrolled students unofficially dropped out, which means they did not attend classes any more but were still enrolled in the course or attended occasionally. Because of such different numbers, any comparison of the expectations and final results is not possible. For example, in P2 surveys 14 students expected grade 5, and 13 students actually got that grade. Since results were anonymous, it is not possible to know if those 13 students are really those who expected it.

Next, grade average for students that passed P1 and P2 were compared with grade averages for courses DSA and OOP. In the year 2010/11 students achieved average grade 3.19 in P1, 2.64 in P2, 3.12 in DSA and 3.09 in OOP. There is a trend of higher grades in programming courses after first year for students that pass P1 and P2.

4. Conclusion

Students that enroll undergraduate programming courses at the FOS are mostly novices without any programming experience. The first year programming courses are impassable obstacle for many students. Since different researchers hint that mathematical abilities affect programming as we stated above, the correlation analysis was conducted and there is high correlation between students' success in introductory programming and mathematical courses. Curriculum for programming courses should be closely examined to determine if assignments and presented concepts possibly favor mathematical way of thinking. Courses after second semester consist of students that pursued their educational path beyond first obstacles. Some of them continue to struggle and fail because introductory programming courses could be their top potential.

Students' perception and final grades differ in percentages, but there is too high difference in the number of students that enrolled courses and students that participated in the survey. Since it was not possible to compare results, the conclusion is that students should be surveyed about their expectations directly (not anonymously). Such results would be comparable and researchers would be able to determine if students' expectations match actual results. Sometimes students have too high expectations, but sometimes exam assignments might be inappropriate.

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