

# Exploring the Psychological Predictors of Programming Achievement

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The main purpose of this study is to explore the predictors of programming achievement. With this aim in mind, the students' success in the programming courses is specified as the dependent variable and creativity, problem solving, general aptitudes, computer attitudes and mathematics achievement are specified as the independent variables. A correlational design was used to explain the relations between dependent and independent variables. The study group consists of 48 high school students in Profilo Anatolia Technical High School, Istanbul. At the end of the study, significant relations were found between the students' programming achievement and their general aptitudes and mathematics achievement. Also, in order to determine the predictors of the students' programming achievement, multiple regression analysis was applied. The findings reveal that only one variable that significantly predicts the students' programming achievement is general aptitude.

There have been many studies in recent years into academic success in computer programming (McNamarah & Pyne, 2004; Byrne & Lyons, 2001; Begum, 2003; Fowler and et al., 2002). Today, industry is keen to accept as many graduates as the academic institutions can produce, and there is an assumption that any bright student can be successful in computer programming. However, experience in the classroom would suggest that this is not true. Students who are proficient in many other subjects sometimes fail to achieve success in programming (Byrne & Lyons, 2001), because programming is different from other discipline.

The developments of programming languages and methods, and the teaching of them, have up to now hardly been linked to a psychological study of the activity of programming. Psychology must go beyond the procedural aspect of programming; because

it is becoming more and more important nowadays due to the variety of applications and the training that programmers receive (Hoc and et al., 1990). Prior research indicates that standardized measures of aptitude (e.g. SAT and ACT scores), prior academic performance (e.g. high school GPA) and effort or motivation explain a significant portion of the variation in student performance (Eskew & Faley, 1981; Hostetler, 1983; Goold & Rimmer, 2000).

In a review of studies attempting to predict programming achievement done up to 1990, Hostetler and Corman make a specific case for the inclusion of cognitive factors in any study of this kind (Hostetler, 1983; Corman, 1986). They found that some of the demographic, academic, computer exposure or cognitive variables were particularly strong predictors of class performance. According to Taylor and Mounfield (1989) prior experience in programming provides a significant predictor of how students perform in the programming courses. They founded that prior exposure whether at the high school or college level is an important factor to students' success in computer programming.

Also, the link between mathematics ability and programming is widely accepted.

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Several of the reviewed studies showed that success in Mathematics was a good predictor of success in computer science (Byrne & Lyons, 2001; Fowler and et al., 2002; Werth, 1986; Campbell, 1984; Chmura, 1998). There is a belief that the concepts which a student has to comprehend in order to master mathematics problems are similar to those for programming (Byrne & Lyons, 2001; Werth, 1986).

Besides those there appears to be a number of factors which influence the success in the programming. In general the reviewed research found correlation between computer attitudes and computer programming (Dey & Mand, 1986; Austin, 1987). Also, earlier studies indicated that demographic data impacted on programming success (Byrne & Lyons, 2001; Goold & Rimmer, 2000; Grant, 2003). Five factors were reviewed as potentially predictive to success in programming. They included problem solving ability, motivation, learning style, previous experience, and gender. Even though these variables are helpful in predicting success in computer programming, it appears that they could also predict success in other fields. These findings reveal that programming ability is different from other skills.

Considering all these points, the current study hopes to explore the correlations between students' programming achievement and their creativity, problem solving ability, general aptitudes, computer attitude, and mathematics achievement. With this aim in mind, research questions can be stated as follows;

1. Is there a significant relationship between the students' programming achievement and their creativity, problem solving ability, general aptitudes, computer attitudes and mathematics achievement?
2. Are there any mental factors that significantly predict the students' programming achievement? If so, what are they?

## Methodology

### *Research Method*

In the current study, a correlational design was used to investigate relations between students' programming achievement and their creativity, problem solving ability, general aptitudes, computer attitude, and mathematics achievement.

For the courses, C programming languages was chosen that aims to introduce the students the basic concepts of structured programming: variables, standard functions, subprograms, selection statements, loops, text files, user defined data types, records, pointers, dynamic data structures. Also, to familiarize the student with the C programming language terminology and to create data structures. The courses contains two hours application per week so beside lecturing students will construct their knowledge in laboratories by doing the assignment project to the groups and by doing the regular homework designed for the laboratory.

### *Participants*

The study was conducted in 2005-2006 education year and the sample of this study consisted of 48 students from Profilo Anatolia Technical High School, Istanbul. This school aims particularly to equip the students with computer and educational technologies. The students are capable of computer technologies and programming languages. 25% of the sample was female while 75% of them were male.

### *Instruments*

In this study 5 different measurement tools were used which are programming achievement test, KAI creativity scale, problem solving inventory, general skills test battery, and computer attitude scale. To determine the students' success in mathematics lessons, the first semester grades were obtained from the school administration. These measurement tools are explained below.

#### *Programming Achievement Test (PAT)*

A multiple-choice test consisting of 25 questions was developed by the researchers in order to specify the students' success in the programming. The validity and reliability studies of the PAT were carried out again by the researchers. After the item analysis 4 items were removed from the test. At the end of the reliability and validity analysis administered with the remaining 21 questions, the cronbach alfa internal consistency was found to be 0.72.

#### *KAI Creativity Scale*

KAI Creativity Scale was developed by (Topaktas, 2001) in order to measure the students' creativity skills contains 33 questions. Students were asked to respond to the statement using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The validity and reliability studies were carried out by Topaktas, and the cronbach alfa internal consistency was found to be 0.89.

#### *Problem Solving Inventory (PSI)*

This scale was designed by (19) which is a five-point likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). PSI measures the attitudes of the students about problem solving and consisted of 38 items. 3 items were removed from the scale because their item total-item remainder correlations were insufficient. The latest version of the scale was found to have an internal consistency coefficient of 0.86.

#### *General Skills Test Battery (GSTB)*

The original form is in French and it has been adapted to Turkish by (Ozcan, 1985). The test measures analytic thinking, abstract thinking and spatial perception. It's a performance test and can be applied to individuals between 15-17 years of age. The test battery containing 113 items has three different dimensions which are; Letter Series (25 items), Shape Recognition (48

items) and Volume Surface Expansion (40 items) (Oner, 1996). The total score from the three different tests of the battery constitutes the students' general skills. The validity and reliability study of the GSTB was carried out again by the researchers and cronbach alfa coefficient was found 0.85 for Letter Series; 0.94 for Shape Recognition and 0.84 for Volume Surface Expansion.

#### *Computer Attitude Scale (CAS)*

Computer attitudes of the students were measured using the Computer Attitudes Scale (Deniz, 1994). This 42-item scale asks participants how frequently they agree with statements such as "Studying with computers is entertaining", "Computers make me angry", and "I believe that computers are beneficial". Participants rated how strongly they agree or disagree with each statement on a five-point scale. Higher scores indicate the greater levels of computer attitudes. There was high internal reliability for this scale; the standardized item alpha was 0.88.

#### *Data Analysis*

A bivariate Pearson's correlation was applied between the students' programming achievement and their creativity, problem solving ability, general aptitudes, computer attitude, and mathematics achievement. In order to obtain the most suitable regression equivalent in explaining the students' programming achievement, multiple regression analysis was used. Multiple regression analysis provides a chance to interpret the total variance of the dependent variable explained by the independent variables and its statistical significance. Programming achievement was included as the dependent variable and other factor as the independent variables. The significance level for all the statistical results in the study was accepted to be 0.05 and all the results were tested two-ways. For statistical analysis the software used was SPSS 13.0.

Results

For the data analysis, first, descriptive statistics were presented. Then, the correlations between the students' programming achievement and the other variables were presented. Lastly, results from the multiple regression analysis were stated.

Variables	Mean	SS	Std. Er.
Programming achievement	66.41	13.28	1.44
Creativity	119.08	10.39	1.50
Problem solving	132.04	13.31	1.92
General aptitudes	52.57	19.60	1.82
Computer attitude	172.68	20.68	2.98
Math. achievement	47.66	17.81	2.57

Table 1 shows the descriptive statistics of the measurements. The mean is 66.41 for programming achievement; 119.08 for creativity; 132.04 for problem solving; 52.57 for general aptitudes; 172.68 for computer attitude, and 47.66 for mathematics achievement.

	Programming achievement	
	r	p
Creativity	0.053	.720
Problem solving	0.072	.626
General aptitudes	0.934	.000
Computer attitude	0.106	.474
Math. achievement	0.447	.001

A bivariate Pearson's correlation coefficients were run to determine the degree of relationship between the students' programming achievement and their creativity, problem solving ability, general aptitudes, computer attitude, and mathematics achievement. General aptitudes and mathematics achievement had significant correlations with programming achievement at the .01 level (see Table 2). However, there was no significant correlation between programming

achievement and creativity, problem solving ability, and computer attitude.

On the other hand, the strongest correlation score was detected between the students' programming achievement and their general aptitudes ( $r=0.934$ ;  $p<0.01$ ). This result indicates that standardized measures of general aptitude scores explain 87.2% of the variation in student performance ( $r\text{-square}_{\text{effect size}}=0.872$ ). This finding reveals that general aptitude is an important factor to students' success in computer programming. The perfect linear correlation between the students' programming achievement and their general aptitudes is presented in Figure 1.

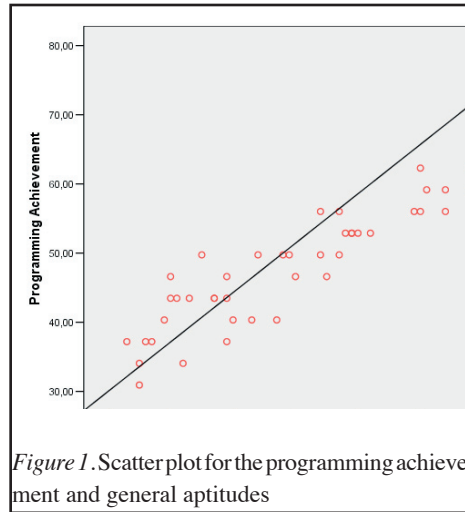


Figure 1. Scatter plot for the programming achievement and general aptitudes

The second highest correlation was computed between the students' programming achievement and mathematics achievement at the level of 0.01 ( $r=0.447$ ;  $p<0.01$ ). According to this finding, 19.8% of the variation in students' programming achievement was explained by mathematics scores ( $r\text{-square}_{\text{effect size}}=0.198$ ). Mathematics, tries to demonstrate numbers, shapes and the relations between these by analyzing them. In this respect mathematics is a demonstrative discipline. Mathematics does this function of demonstrating through reasoning. Reasoning is the common point between programming and mathematics. This finding supports the belief that the

concepts which a student has to comprehend in order to master mathematics problems are similar to those for programming.

<i>Variables</i>	<i>B</i>	<i>t</i>	<i>p</i>
<i>Constant</i>	29.82	3.99	.001
<i>Creativity</i>	-0.08	-1.36	.179
<i>Problem solving</i>	0.06	1.43	.161
<i>General aptitudes</i>	0.48	15.03	.000
<i>Computer attitude</i>	-0.24	-0.87	.388
<i>Math. achievement</i>	-0.02	-0.04	.964

$R=0.939$ ,  $R^2=0.882$ ;  $F=62.845$ ,  $p=0.000$

In order to identify the predictors of the students' programming achievement, multiple regression analysis was applied. As a result, positive relations were detected between the students' programming achievement and independent variables such as creativity, problem solving, general aptitudes, computer attitude and mathematics achievement ( $F=62.845$ ;  $p<0.01$ ). Independent variables explain about 88.2% of the total variance of the programming achievement.

The only variable that significantly predict the students' programming achievement is general aptitudes ( $t=15.03$ ;  $p<0.01$ ). This result reveals that general aptitudes provide a significant indication of how students perform in the programming courses. The regression equation for predicting the students' programming achievement is presented in below:

Programming Achievement = 29.82 + 0.48 general aptitudes + 0.06 problem solving - 0.02 mathematics achievement - 0.24 computer attitude - 0.08 creativity

#### Discussions

The study which investigates the factors influencing their programming performance reveals some noteworthy findings. For example, there is a significant correlation between programming and non-programming

computer performances ( $r=0.621$ ;  $p<0.01$ ). It is quite probable that students' knowledge about computers makes it easier for them to perform better in programming. This supports finding of the earlier studies (Byrne & Lyons, 2001, Goold & Rimmer, 2000, Taylor & Mounfield, 1989).

Other main factor is the general ability. The analysis of results clearly suggests a very high impact of general ability on programming performance ( $r=0.934$ ;  $p<0.01$ ). Ability tests can assess skills on cognitive, verbal, spatial and psycho-motor domains including individuals' powers of comprehension, abstract thinking skills and space perceptions (Ozcan, 1985; Oner, 1996).

It is not surprising that students with high general ability scores perform better in tasks involving computer programming, as it is a skill which necessitates high amount of abstraction capacity in the performer.

The results of regression analysis indicates that student' general ability scores are reliable predictors of their programming performances ( $t=12.083$ ;  $p<0.01$ ) which supported finding of the earlier studies (Austin, 1987).

In this study, it has been revealed that there is a significant correlation between the students' performance in the programming courses and their mathematics achievement at the level of 0.01. ( $r=0.447$ ;  $p<0.01$ ). These results support the theories and researches to date. Several of the reviewed studies showed that performance in mathematics was a good predictor of performance in computer programming (Byrne & Lyons, 2001; Eskew & Faley, 1981; Campbell, 1984; Konvalina and et al., 1983). There is a belief that the concepts which a student has to comprehend in order to master mathematics problems are similar to those for programming (Werth, 1986). This could be that computing as a subject requires a structure and approach with which students have some experience, and similar cognitive skills used in the study of mathematics. Mathematics aptitude is

thus often a pre-requisite for acceptance into computer science programs (Byrne & Lyons, 2001). On the other hand the study has found no correlation between programming achievement and creativity, problem solving, and computer attitude.

There are several limitations of this study. The participants were from a technical high school. Further research could include participants from other institutions like universities. Also, additional researches are needed in order to investigate the other factors that influencing the programming achievement. This study excluded factors such as personal traits, learning styles and demographic factors. These factors could be included in future research.

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