Factors affecting Turkish students' achievement in mathematics

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Abstract: Following past researches, student background, learning strategies, self-related cognitions in mathematics and school climate variables were important for achievement. The purpose of this study was to identify a number of factors that represent the relationship among sets of interrelated variables using principal component factor analysis and examine the contribution of each factor to the explanation of the variance in the students' mathematics score using multiple regression analysis. The sample was prepared from students who participated in Programme for International Student Assessment (PISA) in Turkey. These data consisted of 3765 15 year-old Turkish students in 158 schools. The results showed that four factors under study totally accounted for approximately 34 percent of the variance in mathematics achievement. All of the factors had statistically significant effects on the achievement. The findings are very important for Turkish education system because the fact that changing school climate and improving the learning strategies are much easier to achieve than changing background factors affecting students' performance.

Key words: self-concept; factor analysis; learning strategies; mathematics achievement; PISA

1. Introduction

Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) are the most comprehensive international studies that Turkey has ever participated in. In these international studies, students' achievement in mathematics, science and reading comprehension has been subjected to comprehensive analysis. Besides, many variables affecting students' achievement have been investigated using different kinds of questionnaires.

The PISA is a collaborative effort, involving 30 OECD countries and 11 partner countries, to measure how well 15-year-old students are prepared to meet the challenges of today's knowledge societies. The assessment looks to the future, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the mastery of specific school curricula. PISA is based on a dynamic model of lifelong learning in which new knowledge and skills necessary for successful adaptation to a changing world are continuously acquired throughout life. PISA does assess students' knowledge, but it also examines their potential to reflect on their knowledge and experiences, and to apply that knowledge and those experiences to real-world issues (PISA, 2003).

PISA is an ongoing survey with a data collection every three years. The first PISA survey was conducted in 2000 in 32 countries. The second PISA survey was conducted in 2003 in 41 countries.

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When we examined previous studies which have been published international review, we found that there are many studies about educational achievement using multilevel regression analysis, structural equational model and principal component analysis. However, this kind of study has not been made in Turkey using PISA dataset.

Yayan, et al (2004) investigated a linear structural model to explain the relationships among a set of latent variables, constituted through the use of principal component analysis and confirmatory factor analysis. It is analyzed to explore factors that were influential in explaining students' achievement in mathematics by TIMSS 98/99 data. The results of the study indicated that three factors, students' affective measures, home-family background characteristics and what teachers do in the classroom are the most important variables to explain achievement in mathematics. According to Yayan, what might be required from educational policy makers in Turkey is to consider these three factors together to enhance the quality of educational practices.

Kiamanesh (2004) followed Coleman's report, extensive research has been carried out on in- and out-of-school variables affecting students' achievement such as school factors, self-concept, self-efficacy, attitude, attribution, motivation, press variables, and gender. The purpose of this study was to identify the number of factors that represented relationships among sets of interrelated variables using TIMSS 99 Student Background Questionnaire data (35 items) for Iranian students. The results of this analysis showed that seven of the eight factors under study totally accounted for approximately one fifth of the variance in mathematics score (20.8 percent).

Factors affecting students' mathematics achievement have been the concern of researchers. Some researchers developed models to explain students' mathematics achievement. In these studies, as the predictors of mathematics achievement, as the strategies of memorization, transfer through elaboration and metacognition were studied (Chow, et al., 2007), as well as family and motivation effects (WANG, 2004; Chiu, et al., 2007), attitudinal and motivational variables (Hammouri, 2004).

Moreover, Papanastasiou, et al (2003) presented the Cyprus results, and proposed a model of home environment and school climate on the social participation of ninth graders based on the IEA 1999 CIVIC education study data. The objective was to design a model, using two exogenous constructs-the home environment and school climate, and four endogenous constructs-political interest of the student, political environment of the student, democratic values and social participation of student in social actions. The study demonstrated that political interest and school climate influence political interest and political environment and these endogenous factors influence democratic values of the students.

2. Purpose and significance of the study

The purpose of this study is to identify a number of factors that represent the relationship among sets of interrelated variables using principal component factor analysis and to examine the contribution of each factor to the explanation of the variance in the students' mathematics score using multiple regression analysis.

Although many factors affect on mathematics achievement directly or indirectly, in this study, student background and self-related cognitions in mathematics are the most important factors that contribute most to the Turkish students' mathematics achievement. We thought that this study could be resource for further national and international researches.

3. Data analysis

This survey consisted of 4855 Turkish students in 159 schools. However, students did not answer all

questions, so there were missing data that could reduce estimation efficiency, complicate data analyses; and bias results (Peugh & Enders, 2004). The data for this study describe 3765 students in 158 schools during the 2002-2003 academic years. Data was analyzed using SPSS v15.0.

Fourteen items from the student questionnaire were relevant to the study. First, Kaiser-Meyer-Olkin measure (KMO) and Bartlett's test of sphericity values must be checked for appropriateness for factor analysis. The value of the test statistic for sphericity based on a Chi-Square transformation of the determinant of the correlation matrix was 0.620 and the associated significant level was small (0.000). According to these results, it was concluded that these data do not produce an identity matrix and are approximately multivariate normal. Furthermore, the correlation matrix contained sufficient covariation for factoring. For more information, see Table 1. The data were then subjected to principal component factor analysis with varimax rotation.

Table 1 Optimization results

Kaiser-Meyer-Olkin measure of sampling adequacy		0.620
Bartlett's test of sphericity	Approx. Chi-Square	29577.571
	df	0.910
	Sig.	0.000

Based on the Scree test and eigenvalues over one, four factors were accepted. These factors accounted for 67.857 percent of the variance. Table 2 shows the total variance explained.

Table 2 Total variance explained

Component	Initial eigenvalues			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	4.186	29.901	29.901	3.087	22.052	22.052
2	2.761	19.720	49.621	2.558	18.268	40.320
3	1.396	9.975	59.596	2.467	17.619	57.939
4	1.157	8.262	67.857	1.389	9.918	67.857
5	0.888	6.341	74.198			
6	0.686	4.897	79.095			
7	0.575	4.105	83.200			
8	0.547	3.905	87.105			
9	0.439	3.135	90.240			
10	0.423	3.021	93.261			
11	0.379	2.709	95.969			
12	0.303	2.165	98.134			
13	0.240	1.717	99.851			
14	0.021	.149	100.000			

Note: Extraction method: Principal component analysis.

Description of the items used for defining the four factors is as follows:

(1) "Student background" factor including items related to economic, social and cultural status (ESCS), the highest educational level of parents (HISCED), the highest occupational level of parents (HISEI), Home educational resources (HEDRES) and cultural possessions (CULTPOSS).

(2) "Self related cognitions in mathematics" factor including items related to mathematics self-concept (SCMAT), interest in and enjoyment of mathematics (INTMAT), mathematics self-efficacy (MATHEFF) and mathematics anxiety (ANXMAT).

(3) "Learning strategies" factor including items related to memorization/rehearsal learning strategies

(MEMOR), elaboration learning strategies (ELAB) and control learning strategies (CSTRAT).

(4) "School climate" factor including items related to attitudes towards school (ATSCHL) and student-teacher relations (STUREL).

The 14 items and their factor loadings are listed in Table 3.

Table 3 Factor loadings

Factors	Items	Loadings
Student background	ESCS	0.97
	HISCED	0.83
	HISEI	0.76
	HEDRES	0.63
	CULTPOSS	0.62
Self related cognitions in mathematics	ANXMAT	-0.88
	SCMAT	0.85
	INTMAT	0.73
	MATHEFF	0.59
Learning strategies	MEMOR	0.85
	CSTRAT	0.81
	ELAB	0.80
School climate	ATSCHL	0.80
	STUREL	0.73

According to Table 3, while economic, social and cultural status (ESCS) is the most important variable (0.97), cultural possessions (CULTPOSS) is the less important variable (0.62) in student background for mathematics achievement. Also, there is no difference between items of learning strategies and mathematics anxiety (ANXMAT) variable has strongly negative effect on mathematics achievement.

In order to determine how much of the variance in average mathematics achievement could be explained by four factors that was computed with principal component factor analysis, multiple regression analysis was used. In this analysis, average mathematics achievement is dependent variable and other variables (factors) which are mentioned above are independent variables.

Table 4 Levels of mathematics scores

Level	Scores	
	Minimum	Maximum
0	-	357.77
1	358.78	420.07
2	420.08	482.38
3	482.39	544.68
4	544.69	606.99
5	607.00	669.30
6	669.31	-

Mathematics achievement (MATACH): Mathematics performance of a student is measured four subjects: geometry, algebra, arithmetic and probability. 85 different questions were asked to the students in the questionnaire. Table 4 shows that levels of mathematics score. With the aim of distinguishing mathematical literacy levels, the PISA 2003 project organized all cognitive processes into 7 different groups, depending on the skill and ability required:

What students can typically do? (PISA, 2003)

(1) Level 1: At Level 1 students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined.

(2) Level 2: At Level 2 students can interpret and recognize situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode.

(3) Level 3: At Level 3 students can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies.

(4) Level 4: At Level 4 students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic ones, linking them directly to aspects of real-world situations.

(5) Level 5: At Level 5 students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriately linked representations, symbolic and formal characterizations, and insight pertaining to these situations.

(6) Level 6: At Level 6 students can conceptualize, generalize, and utilize information based on their investigations and modeling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply insight and understanding along with a mastery of symbolic and formal mathematical operations and relationships to develop new approaches and strategies for dealing with novel situations. Students at this level can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments and the appropriateness of these to the original situations.

Table 5 shows the ANOVA output from regression analysis. In addition, Table 5 represents standardized regression coefficients and collinearity diagnostics for the four independent factors and more specifically the Beta weight as well as the estimate of tolerance and the variance inflation factor (VIF). VIF and tolerance values for four factors are 1.000 and these values are acceptable. It is shown that each factor is uncorrelated with the other independent factors.

Table 5 ANOVA output from regression analysis

Model	Sum of squares	df	Mean square	F	Sig.
Regression	11863911.876	4	2965977.969	476.229	0.000*
Residual	23417480.750	3760	6228.053		
Total	35281392.627	3764			

Notes: * Predictors: (constant), student background, self related cognitions in mathematics, learning strategies, school climate; Dependent variable: Average mathematics achievement.

Variance of the residuals at every set of values for the dependent variable is equal and the residuals have univariate normal distribution.

Table 6 shows that all factors have significant effects on the achievement. Although student background and self-related cognitions in mathematics are the major factors influencing students' achievement, we can say that some variables are not included in the regression analysis, because the results of this analysis showed that four factors under study totally accounted for approximately 34 percent of the variance in mathematics score.

Moreover, because of the items in school climate such as "school has done little to prepare me for adult life when I leave school" and "school has been a waste of time" have negative effects on achievement.

Table 6 Unstandardized and standardized regression coefficients for four independent factors

Factors in the equation	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	439.08	1.29		341.39	0.00
Student background	39.33	1.29	0.41	30.58	0.00
Self related cognitions in mMathematics	39.02	1.29	0.40	30.33	0.00
Learning strategies	3.25	1.29	0.03	2.53	0.01
School climate	-8.48	1.29	-0.09	-6.59	0.00

4. Conclusion

This study should be interpreted in terms of its international setting. Our investigation consisted of 3765 15 year-old Turkish students in 158 schools. Past researches were shown that student background, school climate, learning strategies and self related cognitions in mathematics factors are very important for achievement. For this reason, these factors were used in the analysis.

In our study, ESCS variable in student background factor has strongly positive effect on students' mathematics achievement. This finding indicates that high ESCS parents encourage their children to attend college to pursue higher status careers. Overall, exert indirectly affects achievement by operating through selected family processes and then through different academic self-concepts. Similarly, the exert findings have parallels with other studies conducted in developing countries (Fluoris, et al., 1994; Pitiyanuwat & Campbell, 1994).

Another conclusion of this study is that self-related cognitions in mathematics factor have positive effect on the students' achievement. But mathematics anxiety variable in self-related cognitions in mathematics factor has strongly negative effect. This finding is in line with other research studies (Byrne & Shavelson, 1987; Hansford & Hattie, 1982; Leonardson, 1982; Lynch, 1991; Stone, 1988; Taylor & Michael, 1991).

A positive attitude toward school can also be considered as an important school outcome (Haladyna, Shaughnessy & Shaughnessy, 1983). Due to the fact that some of items in school climate factor are negative effects, school climate has a negative value in the equation. A negative school climate on mathematics achievement is an undesired state for high educational aspirations.

The finding that learning strategies factor has positively and statistically significant effect on achievement. Several studies (e.g., Czurchy & Dansereau, 1998) have indicated that relating material to one's own past experiences tends to learning. If students' are supposed to learn control learning strategies, researchers suggest that teachers incorporate this in their daily practice, and work together with pupils over time (Samuelstuen, 2005).

The results of the present study could help teachers and curriculum developers ensure that the utilized educational policies and methodologies would help students improve attitudes toward school and student teacher relations as well as positive self cognitions related in mathematics. The findings are very important for Turkish education system due to the fact that changing school climate and improving the learning strategies are much easier to achieve than changing background factors affecting students' performance. According to this study, some variables affecting on mathematics achievement are not included in the regression analysis. If it is found that the direct and indirect effects on mathematics achievement using path analysis or structural equation modeling, the explanation of the variance in the mathematics score can be increased.

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