FACTORS AFFECTING IRANIAN STUDENTS' ACHIEVEMENT IN MATHEMATICS

Ali Reza Kiamanesh
Teacher Training University, Iran

Abstract

Following 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 is to identify the number of factors that represents relationships among sets of interrelated variables using TIMSS 99 Student Background Questionnaire data (35 items) for Iranian students, and to examine the contribution of each factor on explaining the variance of students' mathematics achievement and the total variance that could be explained by the determined factors. The related data were factored utilizing principal component factor analysis using Varimax rotation. Based on the Scree test and Eigenvalues over one, eight factors were retained. These factors accounted for 50.8 percent of the variance. The combination of items with loadings greater than 0.47 were considered as separate factors. The results showed that seven of the eight factors under study totally accounted for approximately one fifth of the variance in mathematics achievement (20.7 percent). Mathematics self-concept, home background, teaching, and attitude explained 12.3, 5.1, 1.6 and 0.9 percent of the variance, respectively. The variance explained by press, attribution and motivation factors, even though significant, was negligible. It is worth mentioning that school climate did not enter in the equation. The findings of the present study are important for Iranian educational system since changing self-concept and attitude of students towards mathematics and improving the teaching procedures in the classroom are much easier to achieve than changing background factors affecting students' performance

INTRODUCTION

The Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS) are the largest and most comprehensive international studies that Iran has ever participated in. In these international studies students' achievement in mathematics, science, and reading comprehension has been subjected to comprehensive analysis. In addition, numerous background variables affecting students' achievement have been investigated using background questionnaires. Although enormous valid data have been collected in the above-mentioned studies, the number of secondary data analysis carried out on the available data is relatively few.

The preliminary investigations of the TIMSS data in Iran indicated that there is a positive relationship between students' achievement in mathematics and home background variables such as "parents' level of education", "number of books at home", and "possessing dictionary, computer and study desk". However, Iranian students "who come from a family with the highest level of education of either parents" (8% of the students), "possess all the three educational aids" (5% of the students), and "have more than 200 books at home" (9% of the students) score much lower than the international average score (Kiamanesh & Kheirieh, 2001). Furthermore, the relation between the index of mathematics self-concept and math achievement was positive and significant. The math achievement score of Iranian students who benefited from high self-concept was much higher than that of those who had medium or low self-concept (Kiamanesh & Kheirieh, 2001). Moreover, these investigations indicated that students who have positive perceptions or attitudes towards

mathematics showed better achievement in both mathematics and science (Kiamanesh, 1997). Although 54 percent of Iranian students have a high positive attitude towards math, their average mathematics achievement was much lower than the international average or even the performance of their counterparts in other countries (Mullis et al., 2000).

Following the findings of Coleman (Coleman et al., 1966) suggesting that "schools made no difference", extensive research has been carried out on in- and out-of-school variables affecting students' achievement. Considerable research has examined the relationship between students' characteristics such as self-concept, attitudes towards mathematics, home background as well as motivation and students' subsequent academic performance. In general, a consistent pattern of attitudes towards school subjects and achievement in the respective subjects has been confirmed through a large number of studies (McMillan, 1977; Aiken, 1976; Kulm, 1980; Keeves, 1992; Papanastasiou, 2002; Schereiber, 2000). Papanastasiou (2002) showed that there is a positive relation between mathematics attitudes and math achievement. According to Schereiber (2000), those who have positive attitudes toward mathematics have a better performance in this subject. In contrast with these findings, Cain- Caston's study (1993) showed that for the third grade students there was no significant relationship between students' attitude toward mathematics and students' achievement in this subject.

Psychologists define 'attitude' as any strong belief or feeling or any approval or disapproval toward people and situations. We have favorable or unfavorable attitudes towards people, politics, academic subjects, etc. We favor the things we think are good and helpful, and oppose the things we think are bad and harmful (Kagan, 1984). The students' attitude towards an academic subject is a crucial factor in learning and achievement in that subject. Whether a student views herself or himself as a strong or weak person in a specific subject may be an important factor in her or his academic achievement. Stodalsky et al. (1991) mentioned that students develop ideas, feelings and attitudes about school subjects over time and from a variety of sources.

Among the other major findings of TIMSS 1999, students generally had positive attitudes towards mathematics and science, although less so in countries where science is taught as separate subjects at the eighth grade (Mullis et al., 2000).

Many studies have examined students' thinking about school and their attitude towards mathematics (Vanayan, White, Yuen & Teper, 1977, cited in Papanastasiou 2000). Instruction in school settings provides one important and regularly experienced context in which ideas and perceptions about subject matters as well as other cognitive and affective outcomes can be shaped. Lyton (2000) refers to the environmental effects that influence the child's development. These environmental effects may come from extra-parental influences, such as peer groups and social pressures.

In addition to home background and attitudes towards the subject (Kuiper & Plomp, 2001), press variables (or home-school interface), such as friends and maternal pressure for learning mathematics (Martin et al., 2000), are among the factors that construct students' attitudes towards and beliefs about mathematics (Kulm, 1980). Research evidence shows that if an important person encourages somebody to behave in a certain way, he or she will accept it. The influence of an important person is so strong that even the individual may change his or her attitude in agreement with that of the important person's (Berkowitz, 1986).

Papanastasiou (2002) showed that school climate was influenced by the educational background of students and school climate in turn influences teaching. The Videotape Study of TIMSS 1995 from three different countries (Japan, Germany and USA) showed that outside interruptions affect the flow of the lesson and detract from instructional time. Internationally in TIMSS 1999 for both mathematics and science, about one-fifth of the students reported that their classes were interrupted pretty often or almost always (Mullis et al., 2000).

The relationship between mathematics self-concept and math achievement is another area that has been investigated by researchers (Marsh, 1992; Hamachek, 1995). Franken (1994) states that "there is a great deal of research which shows that self-concept is perhaps the basis for all motivated behavior. It is the self-concept that gives rise to possible selves, and it is possible selves that create the motivation for behavior" (p. 443). Most findings in this area showed that those who have higher self-concept, i.e., perceiving themselves more confident in math, have higher scores in mathematics (Wilhite, 1990).

Researchers (Frize et al., 1983; Weiner, 1985) showed that attributions influence students' achievement. Students often attribute their outcomes to variables like hard work, good luck and natural talent. Even though students may attribute their failure or success to the afore-mentioned variables, the efforts that they make in order to learn mathematics at school or do homework at home probably have an effect on their achievement.

Purpose of the Study

The present study has two purposes:

1. To identify a number of factors that represent the relationship among sets of interrelated variables using Principal Component Factor Analysis
2. To examine the contribution of each factor to the explanation of the variance in the students' mathematics score and to determine the total variance that could be accounted for by these factors using Multiple Regression Analysis

Significance of the Study

Mathematics achievement involves a complex interaction of factors that have specific direct effects and/or indirect effects through other factors on school outcome. Although the relationship between math achievement and factors such as self-concept, home background, and attribution has been studied widely, it is important to explore the factors that contribute most to the Iranian students' mathematic achievement. This would help fill the existing gap in the research carried out in Iran in this area. In addition, it could pave the way for more comprehensive research on the comparison of national and international research findings.

Data Sources

The data obtained from population 2 (eighth grade Iranian students who were mostly thirteen years old) in TIMSS 99 were analyzed in this study. A number of 5301 Iranian students participated in TIMSS 99. The data analyzed in this study were related to the students to whom the mathematics achievement test was administered and who completed the entire required items from the Student Questionnaire. Using Pearson Product Moment Correlation Coefficient and research evidence, a tentative list of 47 items from the Student Questionnaire was selected for data analysis. In addition, mathematics achievement score (Rasch score with the mean of 150 and standard deviation of 10) was used as the criterion variable. The selected items were subjected to factor analysis. It is worth mentioning that as a result of factor analysis the number of items decreased to 36.

Data Analysis

Thirty-six items from the Student Questionnaire were relevant to the study. To determine whether there was an underlying structure, a factor analysis was performed. First, the correlation matrix was examined to determine its appropriateness for factor analysis. The On-Diagonal values in the anti-image correlation matrix or KMO values for each of the 36 items were more than 0.45. In addition, the value of the test statistic for sphericity based on a Chi-Square transformation of the determinant

of the correlation matrix was large (0.854) and the associated significant level was small (0.000). Given 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: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.854
Bartlett's Test of Sphericity	Approx. Chi-Square	25535.082
	df	630
	Sig.	.000

Based on the Scree Test and Eigenvalues over one, eight factors were accepted as the most interpretable ones. These factors accounted for 50.8 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	Percent of Variance	Cumulative Percent	Total	Percent of Variance	Cumulative Percent
1	5.445	15.125	15.125	3.502	9.727	9.727
2	3.051	8.476	23.601	2.672	7.423	17.151
3	2.675	7.431	31.032	2.323	6.454	23.605
4	1.983	5.508	36.540	2.068	5.744	29.349
5	1.662	4.617	41.157	1.997	5.547	34.895
6	1.257	3.492	44.649	1.976	5.488	40.384
7	1.140	3.167	47.816	1.960	5.444	45.828
8	1.077	2.991	50.807	1.792	4.979	50.807

Extraction Method: Principal Component Analysis

A brief description of the items used for defining the eight factors is as follows:

- "Students' Attitudes towards Mathematics" Factor including items to determine whether the student likes mathematics, thinks math is an easy subject, likes finding a job that involves math, enjoys learning mathematics, finds math boring and thinks he usually does well in math
- "School Climate" Factor including items related to school environment to determine whether the student had something stolen, skipped the class, and thought he might have gotten hurt and whether the student's friends skipped the class, had something stolen, and got hurt
- "Home Background" Factor including items related to the highest education level of the student's parents, number of books at home, and possessing dictionary or computer at home
- "Mathematics Self-concept" Factor including items related to whether the student thinks he will never really understand math, he is not talented in math, math is not one

of his strength, and mathematics is more difficult for him than for many of his classmates

- "Teaching" Factor including items on activities related to mathematics lessons, i.e., discussing practical problems while teaching a new mathematics topic, using things from every-day life in solving math problems, working together in pairs or small groups, discussing completed homework, and working on math projects
- "External Motivation" Factor including items related to whether student thinks he needs to do well in mathematics in order to enter his desired school, to get his desired job, and to please his parents
- "Press Factor" (home-school interface) including items on whether the student thinks that it is important for his mother, his friends, and himself to do well in mathematics
- "Attribution Factor" (belief) including items to determine whether the student thinks in order to do well in mathematics he needs memorizing the textbook or notes, good luck, natural talent, or lots of hard work studying at home

The obtained factors were named on the basis of research carried out on the TIMSS data (Martin et al., 2000; Papanastasiou, 2000 & 2002; Koutsoulis & Campbell, 2001). The combination of items with loadings greater than 0.47 were considered as separate factors and are defined as follows:

1. Students' attitudes towards mathematics with six items, loadings between 0.58 to 0.78
2. School climate with six items, loadings between 0.47 to 0.74
3. Home background with five items, loadings between -0.49 to 0.79
4. Mathematics self-concept with four items, loadings between 0.54 to 0.72
5. Teaching with five items, loadings between 0.54 to 0.65
6. External motivation with three items, loadings between 0.72 to 0.76
7. Press (home-school interface) with three items, loadings between 0.69 to 0.78
8. Attribution (belief) with four items, loadings between 0.5 to 0.72

The 36 items and their factor loadings are listed in Table 3.

Table 3: Factors Loading

Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6		Factor 7		Factor 8	
Items	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**	**Items**	**Loadings**
The student likes mathematics	.776	Some of student's friends had something stolen	.736	The highest education level of the student's father	.793	The student thinks he will never really understand math	.718	Discussing practical problems while teaching a new math topic	.646	The student thinks he needs to do well in math to enter his desired school	.763	His mother thinks it is important for the student to do well in math	.778	The student thinks he needs to memorize the textbook or notes to do well in math	.722
The student thinks math is an easy subject	.763	The student's friends were hurt	.714	The highest education level of the student's mother	.754	The student thinks he is just not talented in math	.708	Using things from everyday life in solving math problems	.645	The student thinks he needs to do well in math to please his parents	.741	The student himself thinks it is important to do well in math	.775	The student thinks he needs good luck to do well in math	.626
The student likes a job that involves using math	.722	The student had something stolen	.673	Number of books at the student's home	.666	The student thinks math is not one of his strength	.687	Working together in pairs or small groups	.609	The student thinks he needs to do well in math to get his desired job	.723	The student's friends think it is important to do well in math	.691	The student thinks he needs natural talent to do well in math	.624
The student enjoys learning math	.677	Some of student's friends skipped the class	.668	Possessing dictionary at home	-.581	The student thinks math is more difficult for him than for many of his classmates	.537	Discussing completed homework	.547					The student thinks he needs lots of hard work studying at home to do well in math	.495
The student thinks math is boring	-.584	The student thought he might get hurt	.642	Possessing computer at home	-.491			Working on math projects	.536						
The student thinks he usually does well in math	.580	The student skipped the class	.469												

It is worth mentioning that the values given to the options of each item were recoded and/or reversed wherever applicable, and the average value for the whole item set in each factor was computed.

The correlation matrix between the studied factors and the mathematics score (Rasch Score) showed that six of the eight factors had significant correlations with the math score. The factors of mathematics self-concept, home background, and students' attitudes towards mathematics had the highest correlations with the math score (0.353, 0.302, and 0.216, respectively). In addition, the correlation between self-concept and students' attitudes was high (0.452). Correlations between the other two factors, i.e., school climate and external motivation with the mathematics score, were not significant.

Controlling home background did not have much effect on the correlation between mathematics self-concept and the math score nor the correlation between students' attitudes and the mathematics score and the obtained indices were 0.31 and 0.207, respectively. However, after controlling the home background factor, the correlation between mathematics self-concept and students' attitudes increased from 0.452 to 0.47.

Controlling mathematics self-concept resulted in a decrease in the correlation between students' attitudes and home background (from 0.116 to 0.009), home background factor and the mathematics score (from 0.302 to 0.248) as well as students' attitudes factor and the math score (from 0.216 to 0.069). This shows that the relationship between students' attitudes toward mathematics and home background factors, the relation between students' attitudes toward mathematics and math achievement as well as the relationship between home background factor and mathematics achievement depend on math self-concept.

In order to determine how much of the variance in mathematics score could be explained by the above-mentioned factors, Multiple Regression Analysis was utilized. 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). The first factor that significantly entered into the regression equation was mathematics self-concept. Mathematics self-concept accounted for more than half of the explained variance (12.5 percent). The second factor that entered into the regression equation after controlling self-concept was home background and it explained 5.4 percent of the variance in mathematics score. The third and fourth factors that entered into the regression equation, i.e., teaching and students' attitudes toward mathematics, explained significant proportions of the variance in the mathematics score (1.4 and 0.9 percent of the variance, respectively). The last three factors that entered into the regression equation (attribution, external motivation, and press factors) also explained small but significant proportions of the remaining variance in the mathematics score (0.4, 0.2 and 0.2 percent, respectively). School climate factor is the only factor that did not have a significant effect on mathematics achievement. It is worth mentioning that the Standardized Regression Coefficients (Beta) for teaching (-0.135), external motivation (-0.071) and attribution (-0.052) factors were negative. And finally, the overall multiple regression equation that assessed the joint significance of the complete set of predictor factors was significant [$F(7, 3687) = 139.24$, $p < .01$)].

Table 4 shows the ANOVA output from regression analysis. In addition, Table 5 represents Standardized Regression Coefficients and collinearity diagnostics for the seven independent factors and more specifically the Beta weight as well as the estimate of tolerance and the variance inflation factor (VIF). The lowest and highest tolerance and VIF values for the seven factors were 0.62 and 0.948 as well as 1.055 and 1.614, respectively. All the tolerance and VIF values are acceptable and it can be concluded that each factor is completely uncorrelated with the other independent factors.

The inspection of the respective scatter plots for the standardized predicted values against standardized residuals shows that the relationship between the dependent variable and the seven factors is linear and the variance of the residuals at every set of values for the dependent variable is equal.

Table 4: ANOVA Output from Regression Analysis

Variability	Sum of Squares	df	Mean Square	F	Sig.
Regression	76233.55	7	10890.5	139.24	.000*
Residual	288371.8	3687	78.21		
Total	364605.3	3694			

* Predictors: math self-concept, background, teaching, attitudes, external motivation, attribution, and press factors
Dependent Variable: Math Rasch Score (150, 10)

Table 5: Standardized Regression Coefficients and Collinearity Diagnostics for Seven Independent Factors

Factors in the Equation	Standardized Coefficients (Beta)	t	Sig.	Zero-order Correlations	Collinearity Statistics	
					Tolerance	VIF
Math Self-Concept	.241	14.212	.000	.353	.747	1.339
Home Background	.233	15.507	.000	.302	.948	1.055
Teaching	-.135	-8.757	.000	-.130	.901	1.110
Attitudes	.130	6.994	.000	.216	.620	1.614
Attribution	-.052	-3.418	.001	-.049	.937	1.067
External Motivation	-.071	-4.225	.000	.000	.756	1.322
Press Factor	.050	3.113	.002	.108	.818	1.223

*Dependent Variable: Math Rasch Score (150,10)

The analysis of the data by gender showed that from among the eight factors under study seven had significant effects on the girls' mathematics score and totally explained 24.5 percent of the variance in girls' mathematics score. The most important factors affecting the girls' mathematics achievement were self-concept and home background that accounted for 13.6 and 6.9 percent of the variance in the girls' mathematics score, respectively. External motivation, students' attitudes towards mathematics, teaching, press factor and attribution also explained 1.3, 1.2, 1.2, 0.4 and 0.4 percent of the remaining variance in the girls' mathematics score, respectively. Similar to the total performance of both genders, school climate was the only factor that did not have any effect on the girls' mathematics achievement.

Regarding the performance of boys, it should be stated that 19.3 percent of the variance in the boys' mathematics score was explained by six out of the eight factors. Similar to the total performance of both genders and that of girls, the most important factors that explained the variance in the boys' mathematics score were self-concept and home background. These factors explained 12.2 and 4.6 percent of the variance in the boys' mathematics score, respectively. The other four factors which significantly contributed to the explanation of the variance in the boys' mathematics score after controlling the first two factors were teaching, students' attitudes towards mathematics, attribution, and home-school interface. These four factors explained 1.6, 0.8, 0.2 and 0.2 percent of the

variance in the boys' mathematics score, respectively. School climate (as for the girls) and external motivation are the two factors which did not affect boys' mathematics achievement.

In general, the TIMSS data revealed that school climate was not a predictor for Iranian students' mathematics achievement. External motivation had a significant effect on the performance of total sample as well as girls' mathematics achievement. However, it has not affected boys' mathematics achievement. Even though in TIMSS 1999 there was no significant difference between boys and girls regarding external motivation, ($t = 0.995$, $P = 0.325$), there is a lot of practical evidence which shows that girls are more motivated than boys in learning school subjects. For example, in most of the national tests administered in Iran, including the University Entrance Examination, the girls' performance is much better than that of boys.

It is worth mentioning that the self-concept Standardized Regression Coefficients (Beta) for the total sample, girls and boys were 0.241, 0.242 and 0.245, respectively. In addition, the home background Standardized Regression Coefficients for the afore-mentioned groups were 0.233, 0.264 and 0.21, respectively. And finally, Standardized Regression Coefficients for teaching and attribution factors were negative for the above-mentioned groups.

CONCLUSIONS

Education is a complex process and many factors directly or indirectly affect school outcomes. As a result, it is difficult to properly define the major factors influencing students' achievement. This study similar to abundant research carried out in this field revealed a significant effect of math self-concept, (Kiamanesh & Kheirieh, 2001; Marsh, 1992; Hamachek, 1995; Franken, 1994; Wilhite, 1990), home background (Kiamanesh & Kheirieh, 2001; Wilhite, 1990), students' attitudes towards mathematics (Marsh, 1992; Hamachek, 1995; McMillan, 1977; Aiken, 1976; Kulm, 1980; Keeves, 1992; Papanastasiou, 2002; Schereiber, 2000) teaching, attribution (Frize et al., 1983; Weiner, 1985), press variables (Kulm, 1980; Berkowitz, 1986) and external motivation on mathematics achievement.

The proportion of the variance accounted for by math self-concept was more than twice as much as the variance explained by home background for the total sample as well as for girls and boys. In addition, the proportion of the variance accounted for by self-concept is almost 50 percent of the total variance explained by the other seven factors for the total sample as well as for girls and boys. This is similar to Fuller's finding (1987) that in developing countries school has a great influence on students' achievement after accounting for the effect of home background. Self-concept is not innate, but is developed by the individual through interaction with the environment and reflecting on the interaction.

In general, self-concept refers to a complex system of learned beliefs, attitudes, and opinions that each person holds (Purkey, 1988) and is perhaps the basis for all motivated behavior. Franken (1994) states there is an increasing body of research which shows that it is possible to change the self-concept. Self-change is not something that people can will but rather it depends on the process of self-reflection. Through self-reflection, people often come to view themselves in a new, more powerful way, and it is through this new, more powerful way of viewing the self that people are able to develop possible selves. In addition to the self-concept factor, students' attitudes toward mathematics is the most important students' characteristic that has positive Standardized Regression Coefficient in predicting students' mathematics achievement.

In general, the implication of these findings could serve as a guideline for teachers, educational practitioners and curriculum developers so that they can ensure that the utilized educational policies, methodologies and activities would help students improve their academic self-concept as well as positive attitudes toward school subjects including mathematics. The findings of the present study are important for Iranian education system due to the fact that changing academic

self-concept and attitude of students towards mathematics and improving the teaching procedures in the classroom are much easier to achieve than changing background factors affecting students' performance. The obtained results could serve as a basis for developing a hypothetical model for studying the direct and indirect effects of the afore-mentioned factors on mathematics achievement using Path Analysis or Structural Equation Modeling.

Hereby it seems necessary to refer to a limitation of the present study. According to Bandura (1997), the real performance of students could be measured only when they are motivated to do well in a test. This can happen when the test result is important for the students' academic performance. Since performance in TIMSS did not contribute to formal scores in school records, it is hard to believe that students have tried their best in the TIMSS Study. The way students handle a non-stake test to some extent depends on the prevailing mentality and values of the individual members of the society which is, in turn, the result of the education and upbringing each individual receives from the society in general. Considering this statement as a possibility, the observed differences in mathematics achievement as well as factors affecting students' achievement in different countries might be a function of the way students challenge demanding situations.

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