



**RELATIONSHIP BETWEEN STUDENTS' SELF-BELIEFS AND ATTITUDES ON  
SCIENCE ACHIEVEMENTS IN CYPRUS: FINDINGS FROM THE THIRD  
INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS)**

**Alexandros Mettas  
Ioannis Karmiotis  
Paris Christoforou**

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**ABSTRACT.** The attitudes and self-beliefs revealed in science education can affect students' achievements. Several studies have found that students' self-beliefs are significantly associated with achievement outcomes. The purpose of this study was to investigate the relationship between their attitudes and self-beliefs and science achievements based on TIMSS 1999 results concerning Cyprus. Links between evidence of students' achievements and their relation on positive attitudes and self-beliefs towards science education have been investigated. A number of parameters concerning the effects of attitudes and self-beliefs in relation with their achievement were identified from the study. Several specific self-beliefs were examined and variance estimation statistical techniques were employed. The analysis of the results was based on Varimax factor analysis and stepwise multiple regression analysis. The results of this study indicate that several specific self-beliefs and attitudes were associated with higher levels of science achievement of the Cypriot students in this sample. In addition, these findings provide a number of directions for further research.

**KEYWORDS.** Science, TIMSS, Self-Beliefs, Attitudes, Education.

### **INTRODUCTION**

Students' self-beliefs and attitudes play an important role in the teaching and learning process of science. Those factors can affect students' progress and interest within the subject and as a result students' achievements and learning. The results from the third international mathematics and science study, TIMSS 1999, give a great opportunity for researchers to analyse the effect of students' self-beliefs and attitudes on science achievement test scores.

The Third International Mathematics and Science Study (TIMSS) represents the largest, most comprehensive and most ambitious international comparison study yet conducted (Martin et al 2000; Papanastasiou, 2000). The study provides the participating countries with a solid basis for examining their students' performance from an international perspective.

### ***About TIMSS***

TIMSS 1999, also known as TIMSS-Repeat or TIMSS-R, is a reproduction of TIMSS (1995) at the lower -secondary, the eighth grade in most countries. The International Association conducted the original TIMSS and TIMSS 1999 for the Evaluation of Educational Achievement (IEA). As follow-up to the earlier study, TIMSS 1999 adds to the richness of the TIMSS data. The aim is to improve the teaching and learning of mathematics and science for students everywhere by providing data about what types of curricula, instructional practices, and school environments result in higher student achievement.

The number of countries that participated in TIMSS 1999 was 38 with more than half a million students included in the sample. Each participating country designated a national center to conduct the activities of the study and a National Research Coordinator (NRC) to implement in accordance with international procedures. The quality of the study depends on the work of the NRCs and their colleagues (Martin et al., 2000).

### ***Literature Review***

The study of attitudes began in social psychology during the early part of the twentieth century. From the beginning the study of attitudes has been "characterized by an embarrassing degree of ambiguity and confusion" (Fishbein and Ajzen, 1975, p. 1). One of the earliest definitions came in 1928 when Louis Thurstone defined attitude as the "sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats, and convictions about any specific topic" (p. 531).

Triandis (1971, p. 2), defined attitude as, "an idea charged with emotion which predisposes a class of actions to a particular class of social situations." Triandis (1971) suggests that attitudes consist of three components: (a) a cognitive component, which is a way for humans to categorize ideas, (b) an affective component, which is the emotion that charges the idea, and (c) a behavioral component, which guides behavior. As Mueller (1986) points out "while there is not total consensus among social scientists regarding the definition of attitude, there is substantial agreement that affect for or against is a critical component of the attitude concept" (p. 2).

A belief can be a statement of known fact, a hypothesis about nature or social institutions, a statement about one's own objectives and beliefs, a statement about another decision maker's objectives and beliefs, or an axiom of logic. The decision maker's ability to define its own objectives entails certain self-beliefs (for example, in knowing their own preference).

Several studies that followed the publication of the TIMSS study as well as many previous studies, have indicated that there is a significant association between student self beliefs and attitudes with achievement outcomes. For example, House (1993), found that students self-appraisals of their overall academic ability were significantly related to grade performance in their science courses. Gardner (1975), presented reviews that suggest the correlation between science attitude and various achievement measures is positive. Bloom's (1976) educational theory provided a historical basis for science educators' investigations on these relationships. According to another survey based on the TIMSS data, 8th grade students with more positive attitudes show higher average mathematic achievement (Cheng and Seng 2001). Furthermore it has been supported that learner's beliefs about their capacities exert a strong influence on task performance (Seggers and Boekaerts, 1993). Finally, there is an increasing recognition of the relationship between students' affective characteristics and their subsequent achievement outcome. The belief that positive affect might lead to positive achievement outcome is fairly widespread.

Studies by Fraser and Butts (1982) contradict the views presented above and thus conclude that the empirical evidence is insufficient to support the claim that attitude and achievement are highly related. Moreover, studies have revealed that attitudes and beliefs cannot be used to predict students' outcome in mathematics (Papanastasiou, 2000). Supporting this view, the findings by Fraser and Butts (1982) showed little correlation between attitudes and achievement. Finally, Eisenhardt's (1977) research indicated that achievement influences attitudes more than attitudes influence achievement in mathematics.

Researchers have operationalized self-beliefs and attitudes towards science in many different ways. This has lead to a diversity of the studies outcomes, making it difficult to compare results. According to the results of TIMSS 1999 (Martin et. al, 2000), there is a clear positive association between self-concept and science achievement. Internationally, 26 percent of students on average have a high self-concept in the sciences. The relationship concerning the country level was more complex. Several countries with high average science achievement, including Singapore, Japan, Hong Kong, Chinese Taipei, and Korea, have relatively low percentages (21 percent or less) of students in the high self-concept category. Since all of these are Asian Pacific countries, they may share cultural traditions that encourage a modest self-concept.

Generating positive attitudes towards science among students, there is an important goal of science education in many countries. To gain some understanding about students view regarding the utility of positive attitudes towards the sciences, TIMSS-R study indicated a number of related statements (Martin et. al, 2000). From the results it can be seen that students generally have positive attitudes towards the sciences. Countries with large percentages of students at the high level included Malaysia, Philippines, Tunisia, Jordan, South Africa, Iran, and

Indonesia, with more than half the students in this category. The countries with the least positive attitudes were Japan and Korea. Australia, Chinese Taipei, and Hong Kong were also low in percentages. Since all these are countries with high average science achievement, it may be concluded that the students follow a demanding science curriculum, one that leads to high achievement, but have little enthusiasm for the subject matter. However, there was a clearly positive association between attitudes towards the sciences and science achievement on average and in many of the countries overall.

The purpose of this study is to investigate the relationship between students' self-beliefs and attitudes towards science with their academic achievements in science. In the study data from the Cyprus model of the Third International Mathematics and Science Study is used. Previous research findings from students enrolled at single institutions have indicated that significant correlations exist between students' beliefs and their achievement outcomes. This study intended to examine the generality of those findings in a cross-cultural context.

### ***Method Used***

This paper is dealing with the results of the third international mathematics and science study for Cyprus. For the purpose of this study the population used (population 2) consists of 13-year-old students studying in their eighth year (the second of the three years in the lower high schools). The students completed questionnaires on home and school experiences related to learning mathematics and science. This study examined data gathered from students' tests in science. The number of schools that participated in this project was 61 and consists of the entire high schools in Cyprus.

### ***Procedure Used***

The Varimax Factor Analysis Method is used in order to categorize the questions into factors, due to the fact that there were various parameters that aimed the definition of attitudes and self-beliefs. The Factor Analysis is a generic name given to a class of multivariate statistical methods, whose primary purpose is to define the underlying structure in a data matrix. Broadly speaking, it addresses the problem of analyzing the structure of the interrelationships (correlations) among a large number of variables by defining a set of common underlying dimensions, known as factor (Hair, Anderson, Tatham and Black 1995).

According to the factors that came up from the above analysis, stepwise multiple regression procedures were used to simultaneously assess the relative contribution of each factor towards the explanation of the science achievement.

## ANALYSIS OF THE RESULTS

### *Grouping the variables*

A number of statements from the questionnaire, within TIMSS study, are grouped together into a number of factors in order to make the analysis of the results more reliable. For the purpose of this study, student variables - included in the model - are determined on the basis of factor analysis. The method used is based in Varimax Factor Analysis. On the basis of the TIMSS-R data about Cyprus, one of the variables, which had been assumed as part of the above factors, was excluded from further analysis so that out of the 18 observed variables only 17 remained for further analysis. The results from the analysis are shown in Table 1.

**Table 1.** Results from the Factor Analysis

#### Rotated Component Matrix<sup>a</sup>

	Component			
	1	2	3	4
I would like science if it were not so difficult	.655			
Although I do my best, science is more difficult for me than for many of my classmates	.752			
Nobody can be good in every subject, and I am just not talented in science	.754			
Science is not one of my strengths	.742			
To do well in science at school you need lots of natural <talent/ability>			.843	
To do well in science at school you need good luck			.828	
To do well in science at school you need lots of lots of hard work studying at home				.815
To do well in science at school you need to memorize the textbook or notes				.718
How much do you like science	.626			
I enjoy learning science	.539	.559		
Science is boring	.601			
Science is an easy subject	.526			
Science is important to everyone's life		.651		
I would like a job that involved using science		.694		
To get the job I want		.827		
To please my parents				
To get into the <secondary school> or university I prefer		.774		
To please myself		.653		

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

The question stating, "I need to do well in science to please my parents" is excluded from further study because it is unable to fit within the factors specified above. The question "I enjoy learning science" is found in both the first and the second factor. In the following analysis, this variable will be included only in the second factor due to its higher value compared with the one given in the first factor.

The four categories arising from the factor analysis are discussed below.

1. Students' self-concept in Science. This factor includes the variables related with personal views of students about science. The statements related to this factor are:

- I would like science if it were not so difficult
- Although I do my best, science is more difficult for me than many of my classmates.
- Nobody can be good in every subject and I am just not talented in science.
- Science is not one of my strengths.
- How much do you like science?
- Science is boring.
- Science is an easy subject.

2. The importance of science in everyday life and the educational expectations of the students'. This factor includes variables regarding students' future plans and the significance of science in everyday life. The statements related to this factor are:

- I enjoy learning science.
- Science is important to everyone's life.
- I would like a job that involves using science.
- To get the job I want.
- To get into the secondary school or university I prefer.
- To please myself.

3. Beliefs of students' concerning the ability to do well in science related with good luck and natural talent. This factor concerns the association of non-academic variables that may affect students' scores in science. The statements related to this factor are:

- To do well in science at school you need lots of natural talent.
- To do well in science at school you need good luck.

4. Beliefs of students' concerning the ability to do well in science related with hard work and memorizing textbook notes. This factor concerns variables, which are associated with the effort needed in order to achieve high scores in science. The statements related to this factor are:

- To do well in science at school, you need lots of lots of hard work and studying at home.
- To do well in science at school you need to memorize the textbook or notes.

### ***Factor Scores***

Further analysis for the factors obtained was carried out estimating the factor scores. A factor can be described in terms of the variables measured and the relative importance of each variable for that factor. Therefore, we should be able to calculate a person's score on a factor, based on their scores for the constituent variables (i.e., a "composite score" for each individual on a particular factor). Stepwise regression analysis was conducted for the factor scores.

Findings from the multiple regression analysis of the relationship between self-concepts and science achievements are summarized in Table 2.

**Table 2.** Stepwise Regression analysis for the factor scores

Step	Variable	R Sq	Adj RSq	B	Beta	F
1	Factor 3: Students' belief concerning the ability to do well in science related with good luck and natural talent.	.182	.182	-32.326	-.427	618.475*
2	Factor 1: Students' self-concept in Science	.254	.253	-20.249	-.267	471.626*
3	Factor 4: Students' belief concerning the ability to do well in science related with hard work and memorizing textbook notes	.315	.314	-18.717	-.247	424.728*
4	Factor 2: The importance of science in everyday life and the educational expectations of the students	.325	.324	-7.705	-.102	333.945*

Note: \*  $p < .01$ .

When all four factors included in the analysis were considered simultaneously, all of them significantly entered the multiple regression equation. The table above shows that factor 3, Beliefs of students concerning the ability to do well in science related with good luck and natural talent, appears to contribute to the prediction of the performance in science, within the frame of the TIMSS study. The contribution of this factor to  $R^2$  was .182. When the factor 1 entered the  $R^2$  became .254, suggesting that this variable added .072 (.254 - .182) to  $R^2$ . The factor 4 added a further .061 (.315 - .254). Finally, the second factor contributed a further 0.01 (.325-.315) to the explanation of the variance in science achievements test scores, indicating that 32.5 per cent of the variance in science was explained by these four factors.

### ***Analysis of the Factors Obtained***

Further analysis included least squares multiple regression procedures. Stepwise regression analysis was conducted for the entire sample including the four factors mentioned above.

### Factor 1: Students self concept in Science

Findings from the multiple regression analysis of the relationship between self-concepts and science achievements are summarized in Table 3.

**Table 3.** Stepwise Regression analysis for the first factor

Step	Variable	R Sq	Adj RSq	B	Beta	F
1	Although I do my best, science is more difficult for me than for many of my classmates	.262	.262	-28.220	-.334	1031.418*
2	I would like science if it were not so difficult	.289	.288	-11.845	-.132	589.236*
3	Science is not one of my strengths	.303	.302	-8.813	-.110	420.227*
4	Nobody can be good in every subject, and I am just not talented in science	.309	.308	-8.913	-.102	324.333*

Note: \*  $p < .01$ .

When all seven variables included in the first factor were considered simultaneously, four variables significantly entered the multiple regression equation. This is a result of the stepwise selection, which eliminates variables that reduce the significance of independent variables already considered.

The table above shows that the students' self-concept in Science appears to contribute to the prediction of the performance in science, within the frame of the TIMSS study. The contribution of the first variable to  $R^2$  was .262. When the second variable --- entered the  $R^2$  became .289, suggesting that this variable added .027 (.289 - .262) to  $R^2$ . The third variable added a further .014 (.303 - .289). Finally, the fourth variable contributed a further 0.06 (.309 - .303) to the explanation of the variance in science achievements test scores, indicating that 30.9 per cent of the variance in science was explained by these four variables. From the above results it is possible to conclude that students who tended to show lower science achievement test scores were more likely to indicate that they were facing difficulties in the understanding of the nature of science.

### Factor 2: The importance of science in everyday life and the educational expectations of the students.

Findings from the multiple regression analysis of the relationship between the importance of science in everyday life and the educational expectations in science achievements are summarized in Table 3.

When all six variables included in the second factor were considered simultaneously, five variables significantly entered the multiple regression equation. The Table 3 shows how the importance of science in everyday life and the educational expectations of the students in science



**Table 3.** Stepwise Regression analysis for the second factor

Step	Variable	R Sq	Adj RSq	B	Beta	F
1	I enjoy learning science	.068	.068	-16.219	-.174	220.818*
2	To get into the <secondary school> or university I prefer	.080	.079	-12.726	-.159	130.949*
3	To get the job I want	.089	.089	15.572	-.190	98.514*
4	Science is important to everyone's life	.099	.098	-10.571	-.107	82.987*
5	I would like a job that involved using science	.106	.104	-8.318	-.106	71.019*

Note: \*  $p < .01$ .

appear to contribute to the prediction of the performance in science, as part of the TIMSS study. The contribution of the first variable to  $R^2$  was .068. When the second variable was entered the  $R^2$  became .080, suggesting that this variable added .012 (.080 - .068) to  $R^2$ . The third variable added a further .009 (.089 - .080). The next variable contributed a further 0.01 (.099-.089). Finally, the fifth variable added a further .007 (.106-.099) to the explanation of the variance in science achievements, indicating that 10.6 per cent of the variance in science was again explained by these five variables.

From the above results it is possible to conclude that students who tend to show higher science achievement test scores were more likely to indicate that they enjoyed learning science. They were also expected to consider science as an important subject for their future career.

### Factor 3: Beliefs of students concerning the ability to do well in science, related with good luck and natural talent

Findings from the multiple regression analysis of the relationship between the importance of the students' beliefs related with good luck and natural talent, in association with their achievements in science, are summarized in Table 4.

**Table 4.** Stepwise Regression analysis for the third factor

Step	Variable	R Sq	Adj RSq	B	Beta	F
1	To do well in science at school you need good luck	.110	.109	-30.707	-.367	364.036*
2	To do well in science at school you need lots of natural <talent/ability>	.113	.112	5.449	.070	188.582*

Note: \*  $p < .01$ .

The table above indicates how the students' beliefs concerning the ability to do well in science related with good luck and natural talent appear to contribute to the prediction of the performance in science, in the TIMSS Exams. The contribution of the first variable to  $R^2$  was .110. When the second variable entered the  $R^2$  became .113, suggesting that this variable added .003 (.113 - .110) to  $R^2$ , indicating that 11.3 per cent of the variance in science was explained by these two variables.

From the above results it is possible to conclude that students who indicated that to do well in science at school you need good luck and lots of natural talent, tended to show lower achievements test scores.

**Factor 4: Students' beliefs concerning the ability to do well in science related with hard work and memorizing textbook notes.**

Findings from the multiple regression analysis of the relationship between the ability to do well in science related with hard work and memorizing textbook notes, in association with their achievements in science, are summarized in Table 5.

**Table 5.** Stepwise Regression analysis for the fourth factor

Step	Variable	R Sq	Adj RSq	B	Beta	F
1	To do well in science at school you need good luck	.110	.109	-30.707	-.367	364.036*

Note: \*  $p < .01$ .

When the two variables included in the fourth factor were considered simultaneously, only one variable significantly entered the multiple regression equation.

The contribution of the variable shown above to  $R^2$  was .031, indicating that 3.1 per cent of the variance in science was explained by this variable.

## CONCLUSIONS

These findings indicate that students' self-beliefs and attitudes are significantly related to science achievement and should be given consideration by instructional designers, when developing science materials and curriculum. These factors should be in mind of any science teacher in order to enable him promote the discussed positive attitudes and beliefs through teaching.

From the analysis of the study, using the least squares multiple regression procedures for the factor scores, we can conclude that the most important factor that affects students' achievement is the factor relating with beliefs of students concerning the ability to do well in science related with good luck and natural talent.

Students who indicated that they enjoy learning science, tended to show higher achievement test scores. Similarly, students who felt that science is important tended to have higher achievement test scores. This is in accordance with the study of Bloom (1976), who predicted that the attitude and subject related self-concept would account for up to 25 per cent of the variability in students' achievement scores. However, students who indicated that either good luck or lots of natural talent are necessary for success in science at school, tended to show lower achievement test scores. When the entire set of variables was considered simultaneously, it was found that student self-beliefs and attitudes towards science were significantly related to science achievement test scores.

These results are consistent with previous research that found significant relationship links between students' attitudes and their achievement outcome (Fraser and Butts, 1982; Cheng and Seng, 2001; House, 1993, Gardner, 1975). According to those studies, positive attitudes towards science could promote better performance and vice - versa. The results were in accordance with other researchers' studies increasing the general application and validity of these findings.

Although Cypriot students show a positive attitude and a high self-confidence for science, their academic achievement is not actually correlated with these factors. The TIMSS data shows that the Cypriot students were listed below the average of the student achievement level in science. Therefore, although attitudes and self-beliefs were positive for the majority of the students, achievement did not duplicate this pattern. However, there are many researchers (Lester et al., 1989) who support that attitudes and beliefs are important factors in the student achievement.

These findings also provide a variety of directions for additional research. For example, these results suggest that students' self-beliefs are significantly related to science achievement test scores. Further study is required in order to determine how self-beliefs and attitudes are related to other types of outcome. Similarly, adequate research is needed to determine whether these relationships can be noted for / applied to students in other countries, within the TIMSS research scheme.

Although TIMSS study gives a great opportunity to investigate various aspects of students' attitudes and self-beliefs in science education, further research is needed with qualitative methods in order to explore in deeper way those important aspects that could affect students' achievements in science education.

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**Alexandros Mettas, Ioannis Karmiotis, Paris Christoforou**

Department of Educational Sciences

University of Cyprus

Phone: 0035722892160

E-mail: [mettas@ucy.ac.cy](mailto:mettas@ucy.ac.cy), [karmioti@hotmail.com](mailto:karmioti@hotmail.com), [parchri@cytanet.com.cy](mailto:parchri@cytanet.com.cy)