Students' Mathematics Performance and their Attitude toward the Learning of Mathematics:

An Attempt to Explore their Relationship

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The present study was an exploratory study aimed at investigating the relationship between Year 7 students' attitudes towards mathematics and their mathematics performance. Using random sampling 29 High Schools were selected from all over the country. The final sample comprised 714 Year 7 students. The research revealed that high performance in mathematics is associated with more positive students' attitudes toward mathematics learning. The most significant finding of the study is that Year 7 students in Greek High schools demonstrated a serious weakness in solving real life problems using the mathematics they have been taught.

Introduction

Mathematics education research in Greece has been fragmented and lacking a sound theoretical framework to guide the researchers in their efforts to unravel the braid of the eternal verities that govern the study of mathematical processes. Recently a number of Greek mathematics education researchers have investigated various mathematics education parameters that underpin the mathematical processes used by students. Studies on students' understanding of mathematical concepts, on mathematics assessment and problem solving have been conducted in the past decade (Kasimatis, 1994; Hionidou, 1996). We tend to believe, however, that the above

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mentioned studies do not provide the necessary and sufficient scaffolding required to implement the attempted reforms in mathematics education in Greece.

The centrally devised curricula and the corresponding secondary school textbooks that have been published in Greece during the past two decades have been primarily based on experiences and studies that have been conducted overseas. They fail to capture the multidimensional and fairly complex singularities of the educational system of Greece. The Pedagogical Institute that has been commissioned by successive Ministers of Education to plan implement and evaluate the mathematics curricula (for both Primary and Secondary schools). The institute has not conducted any research on the degree of students' understanding of various mathematical concepts or on their mathematics performance in relation to cognitive, metacognitive or affective variables.

In the light of proposed reforms in the mathematics education curricula, the Pedagogical Institute conducted the research being reported here, aiming to investigate the relationship between Year 7 secondary students' performance in mathematics and their attitudes toward the learning of mathematics. The spark for the research reported here was ignited by:

(a) The absence of research studies and therefore valid and reliable evidence (in Greece) on how students' attitudes and beliefs affect or even control their performance in mathematics.

(b) Voluminous recent research evidence from studies conducted overseas (McLeod, 1989,1992; Schoenfeld, 1985a, 1989, 1992; Barkatsas & Hunting, 1996; Putt & Isaacs, 1992; Leder, 1993; Lester & Garofalo, 1987; Dreyfus & Eisenberg, 1986; Mandler, 1989; Silver, 1994; Pekhonen & Safuanov, 1996), lends strong support to the inclusion of affective aspects of mathematical problem solving instruction and assessment in school contexts.

(c) The researchers' belief that the study of students' attitudes toward the learning of mathematics is of paramount importance in attempting to improve the learning and teaching of mathematics.

Background Studies

It is our contention that one of the most significant aims of mathematics education is the development of a positive attitude toward mathematics in school-aged students, as well as to encourage young people to actively participate in solving mathematical problems, in modelling real life situations. And in addition to experience the pleasure and fascination of conducting mathematical investigations, thus enabling them to become embedded in potential mathematical microcosms (Schoenfeld, 1992; Barkatsas & Hunting, 1996), in much the same way practising mathematicians experience their mathematical endeavours.

Attitudes and beliefs have attracted a considerable interest in recent research studies (McLeod, 1989, 1992; Schoenfeld, 1989, 1992; Lester & Garofalo, 1987; Barkatsas & Hunting, 1996; Leder, 1992, 1993). A number of definitions have been put forward by various researchers over the past two decades. McLeod (1992), stated that:

> *Beliefs are largely cognitive in nature, and are developed over a relatively long period of time. Emotions, on the other hand, may involve little cognitive appraisal and may appear and disappear rather quickly. Therefore we can think of beliefs, attitudes and emotions as representing increasing levels of affective involvement, decreasing levels of cognitive involvement (p. 579).*

McLeod (1992), further claimed that beliefs, attitudes and emotions can be considered as subsets of affect. A number of researchers (Lester & Garofalo, 1987), have expressed the view that research evidence indicates that beliefs shape attitudes and emotions and that they greatly affect the disposition of students towards mathematics. Pekhonen & Safuanov (1996) argued that students' prior experiences might affect their beliefs at an unconscious level:

> *Pupil's mathematical beliefs usually act as a filter that influences almost all their thoughts and actions concerning mathematics. Pupil's prior experiences of mathematics affect their beliefs completely - usually unconsciously. (p. 33)*

A certain obstacle to progress in this domain is the non-alignment of the terminology used by researchers. A point of convergence however, may be considered to be the agreement of most researchers on the fact that attitudes may be shaped and transformed via appropriately tuned instructional models. Kulm (1980) has postulated that students' attitudes toward mathematics are being shaped when the students are between nine and fourteen years old and they are completely shaped by the age of fifteen. (That's one of the reasons why the study being reported here, has initially targeted a representative sample of thirteen-year-old students).

Additionally a number of studies have investigated areas of the cognitive or the affective domains which could be deemed to be associated with or play an important role in shaping students' attitudes. These studies cover a wide spectrum such as:

- The degree of satisfaction students get by doing mathematics along with the utility and value of mathematics in daily routines (Aiken, 1974);
- The degree of acceptance or non-acceptance of mathematics by students (Kiryluk, 1980; Helfers, 1986; Corbitt, 1984);
- The stress associated with studying mathematics at various levels (Holden, 1987);
- Incentives that could be offered to students being actively involved in the study of mathematics (Aiken, 1976);
- Gender attitudinal differences (Leder & Sampson, 1989; Willis, 1989).

In the light of the previous discussion it is our contention that the study being reported here is the first study to be conducted in Greece, aimed to investigate the relationship between students' attitudes in mathematics and their mathematics performance.

The Study

The theoretical framework for the study is constructivism (e.g. Confrey, 1990; Steffe, 1991; von Glaserfeld, 1991). According to constructivism, mathematical knowledge is not perceived or intuited but it is constructed by reflectively abstracting (Ginsburg & Opper, 1979) from and reorganising sensorimotor and conceptual activity. According to Cobb (1988), mathematical knowledge is an invention of the mind. The teacher who points to mathematical structures is therefore consciously reflecting on mathematical objects that he or she has previously constructed. Communication often breaks down, since teachers and students each construct their own meanings for words and actions in the context of the ongoing interaction. The classroom environment is ripe for miscommunication since the mathematics teacher possesses structures and can visualise mathematical objects that have become part of his/her everyday cognition, that the student/learner are yet to construct. According to recent research literature (Hunting, 1983; Driver & Oldham, 1980; Confrey, 1990; von Glaserfeld, 1991; Steffe, 1991), miscommunication in mathematics classes is the norm rather than the exception. Research evidence (Confrey, 1990) shows that students routinely use "rote" methods to solve particular problems or tasks, having received instruction, but not having developed the desired conceptual understanding.

Constructivism challenges the assumption that there is one -to-one correspondence between student's observable behaviours and the underlying conceptual structures. Constructivism (von Glaserfeld, 1991), thus makes the distinction between teaching and training. Teaching aims at generating understanding, whereas training aims at competent performance. Their beliefs and attitudes affect students' learning behaviour as it has been shown by Pekhonen & Safuanov's (1996) model of factors affecting students' mathematical behaviour. The teacher of mathematics needs to know his or her students' beliefs about mathematics and their mathematical knowledge base, and other factors that affect their mathematical behaviour.

Research objectives

The present study was an exploratory study aimed at investigating the relationship between Year 7 students' attitudes towards mathematics and their mathematics performance. The foci of the study were the following research points:

1) Students' performance on exercises and problems based on mathematical concepts that had been taught during Term I.
2) The influence exercised by factors such as gender, performance and demographic data in shaping students' attitudes toward learning mathematics.
3) The relationship between students' performance in mathematics and their attitudes toward the learning of mathematics.

Method

Sample

Using random sampling 29 High Schools were selected from all over the country. The final sample comprised 714 Year 7 students. The mean age of students was 12 years and 6 months, with a standard deviation of 3 months. The sample gender distribution was 331 girls and 383 boys. The study was conducted during January and February 1996. Table 1 describes the sample by gender and geographical region.

		GENDER		
		Boys	Girls	Total
AREA	Attica	195	133	328
	Country (Rural)	188	198	386
Total		383	331	714

***Table 1**: Sample description by gender and geographical region*

Instruments and Procedures

A translated version of the Fennema-Sherman Mathematics Attitudes Scales was administered as a combined package to students from all over Greece. Students were given two handouts to be answered anonymously. The first handout contained five mathematical tasks, based on the mathematical syllabus they had covered during Term I of 1996. The second handout contained a translated version of the corresponding Fennema & Sherman (1976) questionnaire. Fennema & Sherman (1976) investigated the attitudes of US students toward the learning of mathematics in their seminal research. Fennema & Sherman (1976) have offered a description of the final form of the Scales:

> *Each scale consists of six positively stated and six negatively stated items with five response alternatives: strongly agree, agree, undecided, disagree and strongly disagree. Each response is given a score from 1-5 and on each scale, except the Male Domain Scale, the weight of 5 is given to the response that is hypothesised to have a positive effect on the learning of mathematics. The person's total score on each of these scales is their cumulative total and the higher the score the more positive their attitude. The Mathematics as a Male Domain Scale is weighted somewhat differently. The less a person stereotyped mathematics, the higher the score (p.7).*

Students were given one period (45 minutes) to complete the questionnaire. The research was conducted at each high school separately and a member of the research team and the class teacher or the regional mathematics consultant supervised it.

The assumptions made by the researchers in the selection of the tasks were those students at the end of Term I of Year 7:

(a) Have sufficient knowledge of the four basic operations with natural, rational and decimal numbers and they are in a position to check the accuracy of their results, at least approximately.

(b) They are in a position to model some real life problems using the mathematics they know.

(c) They have developed an understanding of the basic mathematical concepts that form an integral part of the primary school and Year 7 school mathematics curriculum.

A preliminary analysis was conducted aimed at identifying the degree of the students' understanding of the questions, the terminology, the mathematical notation and the language used in the proposed mathematical tasks. Five schools were randomly selected for the preliminary analysis and Year 7 students were given all five tasks. The researchers discussed the tasks with the students and they recorded all their queries and remarks. All remarks were analysed by the research team, all necessary ramifications were explored and finally the mathematical tasks were finalised.

Five mathematical tasks were finally selected to assess students' performance (See appendix).

- Task 1 set to assess students' ability to order decimal numbers and to record this order by using an appropriate mathematical symbol.
- Task 2 set to assess students' ability to mathematize a task via an understanding of the concept of a variable.
- Task 3 set to assess students' ability to perform arithmetic operations.
- Task 4 set to assess students' ability to combine various mathematical operations while attempting to solve a real life problem. This task could be classified as a typical problem for the vast majority of the participants.
- Task 5 set to assess students' critical and synthetic ability. This task too could be classified as a non-typical problem for the vast majority of the participants.

Tasks 1-3 were assigned 10 marks each, task 4 was assigned 42 marks (6 marks for each one of the 7 stages used to decode its solution) and task 5 was assigned 28 marks, which gave a total of 100 marks. This scale was converted to a 1-20 scale (for the calculations of Tables 2a and 2b only), to incorporate teachers' marking policy. The possible solutions for task 5 were coded.

Statistical analysis of the results

The statistical analysis of the results was based on the following data:

- The students' questionnaire answers.
- The students' performance on each one of the five tasks.
- The students' overall performance on the five tasks.
- The students' Term I school mathematics mark.

Mixed Effects Regression Analysis (M.E.R.A.), (Hedeker & Gibbons, 1993) was used to analyse the data. This method provides estimates of fixed and random effects; the latter referring to classroom effects in our study. The sampling method (cluster sampling of classrooms) necessitated the multilevel analysis approach in order to avoid inappropriate statistical conclusions that might lead to a premature rejection of the null hypothesis (Gibbons & Flay, 1994). Attitudes were evaluated by using the Fennema-Sherman method as they (p.9), have originally described it. According to the method any score close to 60 indicates a highly positive attitude toward the learning of mathematics, whereas any score close to 12 indicates a highly negative attitude.

The Mixed Effects Regression Analysis was used to statistically analyse the influence of demographic data such as gender, parents' educational attainment and the school's geographical location exert on students' performance and attitudes toward the learning of mathematics. The dependent variables in each analysis carried out were the following:

(a) Students' performance on the mathematical tasks

(b) Students' school performance during Term I

(c) The 9 Mathematics Attitude Scales

Main analysis of results

In tables 2 and 3 the means and standard deviations of the students' performances on the mathematical tasks, the students' performance at school, the mathematics attitude scales by gender and region are presented. In table 4 a summary of the M.E.R.A. is presented.

Students' mathematics performance

In table 2a we present the mean and standard deviations of students' 1st Term marks in mathematics and the corresponding marks in the written test. The mean difference is approximately 7.2/20 marks. The significant difference between the two measures of performance (1st Term marks and written test) could be attributed to a tendency their teachers have to report marks slightly higher than the actual. This is done in order to boost their students' self-esteem especially during the lower and compulsory secondary years of schooling (Years 7-9) and consequently enable them to graduate.

A significant finding is that the students'' 1st Term score is approximately the same as the score they obtained in the exercises section of the written test, i.e. by disregarding the scores they obtained in the problem section of the test. The scores obtained by the students in the problem section on the other hand differ significantly to that obtained in the problem solving section of the written test. The students' scores in the two problems were not significantly different.

		GENDER					
		Male		Female		Total	
	REGION	Mean	S.D.	Mean	S.D.	Mean	S.D.
TERM 1 SCORE	Attica	13.7	3.0	4.5	2.9	14.0	3.0
	Country	14.4	3.2	15.0	2.9	14.7	3.1
	Total	14.1	3.1	14.8	2.9	14.4	3.0
TOTAL WRITTEN TEST SCORE	Attica	6.7	4.4	7.4	4.2	7.0	4.3
	Country	7.0	4.4	7.6	4.1	7.3	4.2
	Total	6.9	4.4	7.5	4.1	7.2	4.3
EXERCISES SCORE	Attica	13.4	5.8	14.4	5.7	13.8	5.7
	Country	13.7	5.8	14.6	5.6	14.2	5.7
	Total	13.6	5.8	14.6	5.6	14.0	5.7
PROBLEMS SCORE	Attica	3.9	4.8	4.4	4.5	4.1	4.7
	Country	4.0	4.7	4.5	4.5	4.2	4.6
	Total	3.9	4.8	4.4	4.5	4.2	4.6

Table 2a: *Means and Standard Deviations of Term 1 scores in mathematics by gender and region.*

Considering the 1st term's scores there is:

(a) a small advantage in being a country student compared to a student from the Attica region (0.7 scores mean difference; $z = 2$; $p < 0.05$), and

(b) girls appear to perform better than the boys (0.6 scores mean difference; $z = 2.97$; $p < 0.01$).

It was also found (table 2b) that parents' attained educational level exerts a significant influence on students'' 1st Term marks. Students whose parents have a University Degree perform at a higher level in school mathematics. Considering the total number of the mathematical questions used in the research, the only variable that was found to exert a significant influence on performance was the educational level of the parents ($z = 7.35$; $p < 0.001$).

		FATHER'S EDUCATION					
		Primary School (Age 6+)	High School (Age 12+)	Senior High (Age 15+)	Further Educ.	Univ. Educ.	Total
TERM 1 SCORE	Mean	13.2	13.9	15.0	14.5	16.5	14.4
	S.D.	3.0	3.0	2.6	3.1	2.1	3.0
TOTAL WRITTEN TEST SCORE	Mean	5.4	6.3	8.2	8.3	9.1	7.1
	S.D.	3.7	3.8	4.2	4.4	4.5	4.3
EXERCISES SECTION SCORE	Mean	11.7	13.4	15.0	15.6	16.2	14.0
	S.D.	6.3	5.9	5.1	4.6	4.7	5.8
PROBLEMS SECTION SCORE	Mean	2.6	3.3	5.2	5.1	5.9	4.1
	S.D.	3.5	4.0	4.9	5.2	5.3	4.6

Table 2b: *Means and Standard Deviations mathematics scores by level of father's education.*

A number of comments may be made at this stage, regarding the results of the research on students' performances on the *mathematical tasks:*

(a) There was a striking similarity between students' performances (represented by their scores) on the tasks that have been classified by the research team as routine questions (tasks 1-3), and their respective Term 1 marks.

(b) Students' performance on the two mathematical tasks that have been classified as 'problems' (task 4-5) was unsatisfactory even though they were real life problems. This result might mean that not enough emphasis is being placed by mathematics teachers on problem solving and modelling instruction and assessment. Another factor that may have contributed to the poor performance of students in the problem solving section is the fact that problem solving and modelling does not seem to be an important priority of curriculum developers and textbook authors (in Greece), despite the voluminous body of research (Barkatsas & Hunting, 1996; Leder, 1993; Mason, Burton & Stacey, 1985; McLeod, 1989, 1992; Lester & Garofalo 1987; Schoenfeld, 1985b, 1987, 1992; Dreyfus & Eisenberg, 1986; Mandler, 1989; Silver, 1994; Marshall, 1989) on the importance of problem solving, problem posing, modelling and investigations in contemporary mathematics curricula.

(c) The fact that girls were found to perform better overall than the boys, is diametrically opposite to a socially established belief that boys perform better than girls in mathematics do (Hionidou, 1996).

(d) The fact that students from the country regions were found to perform better than their metropolitan counterparts could be attributed to three factors: The first refers to the type of experiences students are being exposed to. In the country regions, product exchanges require calculations, which the students have to perform on a daily basis. The second is the personal effort country students have to invest in their studies since there are fewer or non-existent coaching schools, something that is considered a commodity and a necessity in the metropolitan region. A third factor that may be advanced, is that the socio-cultural activities the country region students may be involved in are very limited compared to that of their metropolitan region counterparts, the result being an environment more conducive to study for the country students.

(e) The better performance of Attica students in the non-typical problem (task 5) may be attributed to a number of factors. The first could well be the fact that their teachers have a greater opportunity to attend a wide range of professional development activities resulting in an increased emphasis being placed by them on problem solving activities in class. The second is that metropolitan region students are being exposed to a wide range of teaching styles and emphases, due to the fact that they attend coaching schools and private tutoring sessions, possibly resulting in improved skills that may be utilised during problem solving subconsciously or even unconsciously. The third one is that their parents' perception about schooling and the importance of problem solving could be reinforcing a more positive attitude regarding problem solving.

Students' attitudes toward mathematics

In table 3a, the means and standard deviations of students' attitude scales toward mathematics by gender and region are presented. It is evident that girls demonstrate a higher level of mathematics anxiety compared to the boys ($\bar{X}_b = 41.8$; $\bar{X}_g = 38.9$; $z = -3.8$; $p < 0.001$).

It is interesting to note that students from the Attica region demonstrate a higher level of *mathematics anxiety* compared to students from Country regions ($\bar{X}_{at} = 39.1$; $\bar{X}_c = 41.1$; $z = 2.1$; $p < 0.05$). Where $\bar{X}_b$ denotes the mean of the boys' anxiety scale; $\bar{X}_g$ denotes the girls' anxiety scale mean; $\bar{X}_{at}$ denotes the Attica region anxiety scale mean; and $\bar{X}_c$ denotes the Country region anxiety scale mean. Anxiety toward mathematics depends on parents' educational level. The more the years of education parents have, the lower the degree of anxiety their children demonstrate (For fathers' education $z = 2.73$; $p < 0.001$, Table 3b).

Regarding the *confidence in learning mathematics scale*, boys were found to be more confident than girls ($\bar{X}_b = 46.5$; $\bar{X}_g = 44.9$; $z = -3.8$; $p < 0.001$). Similarly, students whose parents have attained a higher educational level, appear to be more confident (For fathers' education for example $z = 3.8$; $p < 0.001$), and finally students from country regions were also found to report a higher level of confidence in learning mathematics ($z = 2.36$; $p < 0.005$). It is worth noting that demographic variables in this research, contributed positively on both the anxiety toward mathematics and students' confidence in learning mathematics.

		GENDER					
		Male		Female		Total	
	REGION	Mean	S.D.	Mean	S.D.	Mean	S.D.
MATHEMATICS ANXIETY	Attica	41.0	9.5	38.7	10.8	39.7	10.2
	Country	42.6	10.0	39.7	10.7	41.1	10.5
	Total	41.8	9.8	38.9	10.8	40.4	10.4
CONFIDENCE IN LEARNING MATHEMATICS	Attica	45.5	9.5	44.0	10.0	44.9	9.7
	Country	47.6	9.5	45.4	10.1	46.5	9.8
	Total	46.5	9.5	44.9	10.0	45.7	9.8
ATTITUDE TOWARDS SUCCESS IN MATHEMATICS	Attica	49.5	7.3	50.3	6.9	49.8	7.1
	Country	50.0	7.1	50.9	7.4	50.4	7.2
	Total	49.7	7.2	50.6	7.2	50.1	7.2
EFFECTANCE MOTIVATION IN MATHEMATICS	Attica	42.7	8.4	42.6	8.9	42.7	8.6
	Country	45.3	8.7	46.7	8.3	46.0	8.5
	Total	44.0	8.6	45.1	8.7	44.5	8.7
USEFULNESS OF MATHEMATICS	Attica	50.1	7.3	50.8	7.6	50.4	7.4
	Country	52.1	7.7	52.2	6.9	52.2	7.3
	Total	51.1	7.6	51.7	7.2	51.4	7.4
MATHEMATICS AS A MALE DOMAIN	Attica	41.9	7.2	46.2	6.9	43.7	7.3
	Country	42.3	7.4	46.7	6.8	44.6	7.4
	Total	42.1	7.3	46.5	6.8	44.1	7.4
MOTHER	Attica	50.8	6.5	51.0	6.7	50.8	6.6
	Country	52.1	6.8	52.3	6.4	52.2	6.6
	Total	51.4	6.7	51.7	6.5	51.6	6.6
FATHER	Attica	51.0	7.1	51.1	6.7	51.1	6.9
	Country	52.5	6.7	53.4	5.9	52.9	6.3
	Total	51.7	6.9	52.4	6.3	52.1	6.7
TEACHER	Attica	43.5	8.5	45.5	7.4	44.3	8.1
	Country	45.8	7.6	47.1	7.2	46.5	7.4
	Total	44.6	8.1	46.5	7.3	45.5	7.8

Table 3a: *Means and Standard Deviations of mathematics attitudes by gender and region.*

		FATHER'S EDUCATION					
		Primary School (Age 6+)	High School (Age 12+)	Senior High (Age 15+)	Further Educ.	Univ. Educ.	Total
MATHEMATICS ANXIETY	Mean	39.1	40.4	42.3	39.6	42.3	40.6
	S.D.	10.6	9.7	8.7	11.1	11.2	10.3
CONFIDENCE IN LEARNING	Mean	43.8	45.3	47.3	46.3	47.9	45.8
MATHEMATICS	S.D.	10.2	9.3	7.7	10.6	10.6	9.7
ATTITUDE TOWARDS SUCCESS IN	Mean	48.7	50.2	50.6	51.2	51.7	50.2
MATHEMATICS	S.D.	7.5	6.7	7.6	6.4	6.8	7.2
EFFECTANCE MOTIVATION IN	Mean	43.5	44.8	45.3	44.1	45.2	44.5
MATHEMATICS	S.D.	8.4	7.9	7.8	10.3	9.5	8.7
USEFULNESS OF	Mean	49.7	51.7	52.3	51.9	52.1	51.4
MATHEMATICS	S.D.	7.9	7.2	6.1	7.8	7.7	7.4
MATHEMATICS AS A MALE	Mean	42.7	43.6	44.6	45.2	45.7	44.1
DOMAIN	S.D.	6.9	7.5	7.4	6.8	8.3	7.4
MOTHER	Mean	50.3	51.7	52.7	52.0	51.7	51.6
	S.D.	7.2	6.1	5.8	6.8	6.9	6.6
FATHER	Mean	50.1	51.9	52.8	53.6	53.5	52.
	S.D.	7.2	6.2	6.0	6.1	6.7	6.6
TEACHER	Mean	44.3	45.2	46.5	45.7	46.7	45.5
	S.D.	7.9	7.3	6.9	8.8	8.4	7.8

Table 3b: *Means and Standard Deviations of mathematics attitudes by father's education.*

Regarding the *attitude toward success in mathematics scale*, a more positive attitude has been reported by students whose parents have been awarded a higher education degree ($t = 3.95$; $p < 0.001$). There is no significant difference between the Attica and the Country regions, whereas the small advantage of girls, could not be accounted for ($t = 1.93$; $p < 0.05$).

Regarding the *effectance motivation in mathematics scale*, students from the Country regions appear to report higher levels ($\bar{X}_c = 45.96$; $\bar{X}_{at} = 42.73$; $z = 4.34$; $p < 0.001$).

With regard to the *usefulness of mathematics,* a positive attitude was reported regardless of gender ($\bar{X} = 51.4$). A more positive attitude has again been demonstrated by Country region students ($z = 2.12$; $p < 00.5$).

The *mathematics as a male domain scale*, represents the scale where boys' and girls' opinions differ more dramatically. Girls disagree more than boys that mathematics is a male domain ($\bar{X}_b = 42.1$; $\bar{X}_g = 46.5$; $z = 8.6$; $p < 0.001$). In this scale too, parents' educational level attained influences students' attitudes ($z = 4$; $p < 0.001$).

Regarding the *father and mother scales*, it has been found that parents demonstrate a positive attitude, wanting their children to succeed in mathematics. Parents from the Country region demonstrating an overall more positive attitude ($z = 2.35$; $p < 0.05$ for the mother scale and $z = 4.03$; $p < 0.001$ for the father scale). Parents' higher educational attainment level, was found to positively influence students' performance ($z = 2.35$; $p<0.05$ for the father scale and $z = 5.46$; $p < 0.001$ for the mother).

With regard to the *teacher scale*, a more positive attitude has been demonstrated by girls ($z = 2.99$; $p < 0.01$), Country region students ($z = 3.27$; $p < 0.01$) and students whose parents have a higher level of education ($z = 2.98$; $p < 0.01$).

Mathematics Anxiety

Regarding the attitudes towards mathematics that have been investigated, we consider that *mathematics anxiety* is the one variable that requires further study, since it plays an important role in students' performance in mathematics and consequently their future vocational orientation and success. For this reason the research team decided to investigate this particular variable further (Mathematics anxiety was found to have the lowest mean ($\bar{X} = 40.67$) compared to all other attitudes in this study).

A M.E.R.A. was carried out (Tables 4 and 5), with mathematics anxiety being the dependent variable; the other attitudes, the students' first term mathematics performance and the demographic variables, being the independent variables.

The regression equation used in our study has been documented by Hox (1994, p. 306):

$$\underline{\mathbf{Y}}_{ij} = \gamma_{OO} + \gamma_{pO}\, \mathbf{X}_{pij} + \gamma_{oq}\mathbf{Z}_{qj} + \gamma_{pq}\mathbf{Z}_{qj}\, \mathbf{X}_{pij} + [\underline{\delta}_{pj}\mathbf{X}_{pij} + \underline{\delta}_{Oj} + \underline{\varepsilon}_{ij}] \qquad (1)$$

In equation (1), according to Hox (1994):

> *The part $\gamma_{OO} + \gamma_{pO} X_{pij} + \gamma_{oq} Z_{qj} + \gamma_{pq} Z_{qj} X_{pij}$ is the fixed part, that contains all coefficients. The gammas can be interpreted as raw regression coefficients in a multiple regression....... The part $[\underline{\delta}_{pj} X_{pij} + \underline{\delta}_{Oj} + \underline{\varepsilon}_{ij}]$ contains the random error structure. (p. 306)*

For the purposes of our study (Tables 4 and 5) variable Y represents Term 1 Score, γ_{00} is the overall intercept or fixed regression coefficient, variables X are those defined at the student's level, i.e.: Sex, Father Education, Mother Education etc. Variables Z are those defined at the classroom level, namely the values that remain the same for all students in the same classroom. The products ZX constitute the interactions between the variables Z and X. Estimates for parameters γ_{00}, γ_{p0}, γ_{0q} are also presented in Table 4. Calculations were carried out using the model as many times as the dependent variables e.g.: Term 1 Score, Written Test Score, Anxiety, etc.

The starting point for the model construction is the intercept-only model, expressed by the following equation:

$$\underline{\mathbf{Y}}_{ij} = \gamma_{OO} + \underline{\delta}_{Oj} + \underline{\varepsilon}_{ij} \qquad (2)$$

An analysis for each dependent variable was carried out with no effects, in order to estimate the intracluster correlation given in Table 4. As a case in point we use the analysis of the variable Y (Term 1 Score). The intercept in this case is 11.5, the Sex parameter is 0.65, the Father Education parameter is .51 etc. The difference between girls and boys, keeping in mind that the values of the remaining parameters are constant, is given by the coefficient 0.65, with girls appearing to have an advantage over boys (Sex: Girls = 1 & Boys = 0).

In relation to the Random Effects being reported in Table 4, it is obvious that the variance of $\underline{\delta}_{0j}$ is significant and its value is 0.48. An interpretation of the significance of $\underline{\delta}_{0j}$ is that the mean values among classroom parameters differ significantly with respect to Term 1 Score, even after removing the effects: Sex, Father Education, Mother Education etc. None of the coefficients was found $\underline{\delta}_{pj}$ significant, resulting in the indication ns. for the Random Effects:

Sex, Father Education and Mother Education. The intracluster correlation for the Term 1 Score parameter, which was found to be .06 (Table 4), indicates that using equation (2), it can be calculated that 6% of the variance of the Term 1 Score may be accounted for by the classroom factor.

From the results of the regression analysis it is evident that gender is significantly associated with mathematics anxiety. This finding highlights the need for further research to investigate the interrelationship between gender and mathematics anxiety, especially in the case of girls.

On the contrary, the region and parents' education does not exert a significant influence on mathematics anxiety and they may be considered indirect. The mark students obtained during Term I, is associated with anxiety. Students with a lower mark demonstrated a higher level of anxiety ($b = 0.42$; $z = 3.72$; $p < 0.001$).

Dependent Variable											
Independ. Variable	Term 1 score	Written test score	Anxiety	Confi-dence	Success	Useful-ness	Motiva-tion	Male domain	Father	Mother	Teacher
Fixed effects: student level											
Intercept	11.5***	9.94***	38.7***	42.9***	47.7***	48.1***	42.7***	40***	48.5***	49***	41.9***
Sex	.65**	.65**	-2.9***	-1.7*	ns	ns	ns	4.5***	ns	ns	1.7**
Father educ.	.51***	.62***	ns	1.0***	.77***	ns	ns	ns	.96***	ns	.06**
Mother educ.	.32**	.51***	.8**	ns	ns	.72***	ns	.81***	ns	.68***	ns
Fixed effects: class level											
Region	.73*	ns	2.1**	2.0*	ns	1.89	3.25***	ns	1.95***	1.6*	2.2**
Random effects:											
Intercept	.48*	o.65*	2.9	1.56	0.89	.64	1.12	0	0	1.58*	.79
Sex	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Father educ.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Mother educ.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Residual variance	7.42***	15.4***	99.5***	90.5***	49.1***	52***	71.6	48.6***	41.25***	41.1***	57.9***
Intercluster correlation	.06	.04	.028	.017	.018	.012	.015	0	0	.037	.013

***Table 4:** Parameter estimates of mixed effects regression analysis models.*

Notes: 1. (* for p<0.05); (** for p<0.01); (*** for p<0.001;) ns=non-significant

The effect of one of the attitudes investigated, the effectance motivation ($b = 0.47$; $z = 10.7$; $p < 0.001$), has been found to be positively associated with students' anxiety in doing mathematics. An increased level of involvement in doing mathematics is associated with lower anxiety levels.

Students' realisation that mathematics is useful has been found to have a small effect on their attitude toward mathematics learning ($b = 0.11$, $z = 1.96$; $p < 0.05$).

Regarding the effect of teachers' encouragement on reducing students' anxiety, it was found-as it had been conjectured by the research team-that positive reinforcement by the mathematics teacher results in reduced levels of students' mathematics anxiety.

	Models	
Independent Variable	No effects	With effects at the classroom level
Fixed effects: student level		
* Intercept	40.60***	1.50
* Sex		-4.20**
* Term 1 score		.47***
* Effectance motivation		.51***
* Teacher		.25***
Fixed effects: classroom level		
* Region		ns
Random effects:		
* Intercept	3.05[3]	3.00
Residual variance	104.10[3]	63.40
Intracluster correlation	2.8%	2.1%
Proportional decrease of variance		
* residual		39%
* intercept		0

***Table 5**: Parameter estimates of mixed effects regression analysis models for anxiety.*

Notes:

1. (for p<0.05); (** for p<0.01); (*** for p<0.001;) ns=non-significant*

2. Non significant fixed effects at student level and non significant random effects not presented

3: This variance estimate is the basis for calculating the proportional decrease of variance in subsequent models

Discussion

The results of this research study may be summarised as follows:

With respect to performance

It was found that students' performance on the exercises section of the written test (tasks 1-3), is compatible with their maths teacher's assessment (Term 1 marks). Country students were found to perform marginally better than their Attica (Metropolitan) counterparts; girls perform better than boys do; and students whose parents have higher education, perform better. Students' performance on the problem section of the written test (tasks 4-5), was very poor. The reported difference between the students' school performance and their corresponding problem solving performance is significant irrespective of demographic, gender or parents' education factors. A conclusion that may be drawn from these findings is that mathematics instruction in Greek schools does not focus on problem solving processes.

With respect to students' attitudes toward mathematics

It was found that:

- Anxiety is the dominant factor in determining students' attitudes toward mathematics learning. Girls demonstrated a higher anxiety level compared to the boys, as well as, students from Attica compared to their Country counterparts and students whose parents do not have a higher education.
- Confidence in learning mathematics was found to be higher in boys, Country students and in students with highly educated parents.
- Students whose parents have a higher education degree, were found to demonstrate a more positive attitude toward success in mathematics, whereas no significant difference between Attica and Country students was detected.
- Parents' positive attitude toward mathematics learning, positively influences their children's attitudes too. It was found that parents' positive attitude influences Country students and students whose parents have a higher education, more than the other categories.
- Teacher's positive attitude toward the student, was found to facilitate positive student attitudes and to increase the level of students' self-confidence.

- Most boys were found to agree that mathematics is a male domain, while girls held a diametrically opposite opinion. A re-examination of the items in this scale is required, however, since several items are no longer valid, according to Forgasz, Leder & Gardner (1996). The researchers claimed that:

> *Access to well-designed, valid and reliable psychometric scales is invaluable for the researcher committed to a particular research field. Till now, the widely used MAS have been very effective in fulfilling this role for those investigating gender issues in mathematics education. One of the MAS scales, the MD, is sorely in need of revision. Otherwise, those using it may unknowingly obtain inaccurate measures of the construct "mathematics as a male domain", with the inevitable consequences on data interpretation.* *(1996, Vol. 2 pp. 361-368)*

- Effectance motivation in mathematics was found to be significantly higher in the Country regions compared to the Attica region.
- The usefulness of mathematics was found to be held in high regard by all students irrespective of gender. More positive attitudes were demonstrated by Country students and by students whose parents are highly educated.

In addition the research revealed that high performance in mathematics is associated with more positive students' attitudes toward mathematics learning (Table 6). There is a paradox, however, that has been revealed by the results of this study. Despite the fact that girls were found to perform better than the boys, they demonstrated a significantly higher level of anxiety compared to the boys. Fennema & Sherman (1976) have, also reported the low mean values of the scales concerning mathematics anxiety and confidence, the increased anxiety level of girls as well as their low level of confidence.

Scale	Reliability
Attitude towards Success in Mathematics	.73
Mathematics as a Male Domain	.66
Confidence in Learning Mathematics	.87
Effectance Motivation in Mathematics	.77
Usefulness of Mathematics	.76
Father	.72
Mother	.72
Teacher	.76
Mathematics Anxiety	.83

Table 6: *Cronbach's (α) Reliability Coefficients for the 9 Attitude Scales*

After the final selection of the items Cronbach's coefficient Alpha (α) reliabilities were calculated and these appear in Table 6.

The most significant finding of the study is that Greek Year 7 students demonstrated a serious weakness in solving real life problems using the mathematics they had been taught. This finding wasn't unexpected, but the extent of the weakness was not expected. It is our firm belief that the results of the study should be taken under consideration by the Pedagogical Institute (which is in charge of formulating and reforming the Greek mathematics curriculum), in evaluating students' performance in an important area of the mathematics curriculum, i.e. students' problem solving abilities and weaknesses.

These findings are of interest for more thorough study by utilising research instruments, which will enable the researchers to further probe and analyse the complex area of students' mathematics attitudes toward the learning of mathematics.

At present a large-scale study of Year 9 students' attitudes is in progress in which the insights gained in this study are being empirically tested. In this follow-up study the questionnaire used in this study is being used along with a teachers' attitudes questionnaire and student interviews.

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APPENDIX

Mathematical tasks

1. In the following table insert the correct symbol >, =, < between the numbers in each row.

10.02	10.002
321.3	32.13
9.30	9.3
0.503	5
202.14	212.14
1.0510	1.0051
10,160	10.160

2. Tuition fees for each student at a school of music are 20,000 drachmas per month and the enrolment fee is 5,000 drachmas. *Underline one or more of the following expressions which represents the money each student will pay in x months.*

A. 20,000 + x + 5,000 drachmas

B. 5,000x + 20,000 drachmas

C. 20,000x + 5,000 drachmas

D. 25,000x drachmas

3. *Underline the answer (A, B ,C, D), which corresponds to the numerical value of the following expression:* $c = 40 + 10a - 2.5b$ *where* $a = 3.5$ *and* $b = 2$

A = 65

B = 60

C = 71

D = 70

4. Jason a Grade 6 student, his parents and his two siblings Daphni (9 years old) and Alex (6 years old), were on vacations in a caravan park, with their car. They arrived on August the 12th and they left on September the 8th. The costs associated with their vacations are explained analytically in the following table:

Daily costs				
Persons older than 7 years old	Caravan	Car	Electricity	Dog
1000 drs	400 drs	200 drs	150 drs	50 drs

- Children less than 7 years old pay half price
- The above mentioned prices are available for July and August only
- The prices for the rest of the year are 4/5 of the above mentioned prices
- For families staying longer than 25 days a discount of 25% of the total amount payable is available

If we know that:
(1) Jason's family doesn't have a dog, they are not going to use electricity and they are all staying in the same caravan
(2) August has 31 days
(3) The family will be charged for the 12th of August but not the 8th of September
How much would the vacation cost Jason's family?

5. Two trains are moving along the same railway, in opposite directions to each other with speeds 100 km/h and 80 km/h respectively.
How many kilometres will they be away from each other 1 min before collision?

Denne artikkelen presenterer en undersøkelse som sikter mot å utforske sammenhenger mellom elevenes prestasjoner i matematikk og holdninger til faget. Dataene for undersøkelsen er hentet fra et tilfeldig utvalg av 29 skoler og 714 elever blant alle skoler i Hellas. Elevene i undersøkelsen går i 7. Klasse og har en gjennomsnittsalder på 12 år og 6 måneder. Dette studiet viser at gode prestasjoner i matematikk er forbundet med positive holdninger til det å lære matematikk. Forfatterene peker på at det viktigste funnet i undersøkelsen er at greske elever på dette klassetrinnet viser en alvorlig svakhet når det gjelder å bruke den matematikken som blir undervist i skolen til å løse problemer fra realistiske situasjoner i det daglige liv.

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