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FACTORS THAT INFLUENCE STUDENTS TO DO MATHEMATICS

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Abstract. The aim of this investigation was to study the factors that influence students to do mathematics in a level higher than the usual level arising from the usual syllabus. The sample was 339 students who participated at 25th National Mathematical Olympiad "Archimedes" in March 2008. They completed a questionnaire designed to measure the factors that influenced them to do mathematics. The results of this investigation show that the more important factors affecting students to do mathematics are: Mathematical competitions, their fathers, books, their school teachers, the publications of the Hellenic Mathematical Society and their mothers.

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Key words and phrases: Mathematics competitions; factors of motivation.

Theoretical frame

Education–Motives–Influence

By the term "Education" we mean the general grid of images that a person gets from his environment and it is a fundamental pedagogic concept.

"*Education is the sum of influences a man gets throughout his life from his environment (natural, family, ecological, social and cultural) (Education as interaction), especially during childhood and adolescence, educators (parents, teachers or other factors of systematic education).*" (Kroustalakis [6])

Psychology and Sociology are sciences that actively contribute to the developing evaluation of Pedagogy, based on the fact that the influence of a social group by external factors is an issue of study by Social Psychology.

"*In the last two or three decades the idea that learning, as a procedure as well as content (knowledge), is not an individual subject, as Psychology stated, but socially defined, is getting widely acceptable. The establishment and the function of the institutions that produce and teach knowledge are socially defined. The acceptance of the above aspects turned the attention of pedagogues towards Sociology, which became in this way the second science, after Psychology, that affects and forms pedagogical discussions.*" (Matsaggouras [7])

The influence upon a social group (positive or negative) is more effective when it aims to particular social characteristics that we call motives. By the term *motive* we mean the set of internal and external factors that activate the body and urge it to put some aim and try to achieve it.

H. McFarland mentions that "*motivation activates the energy which ends in learning, keeps it on alert and guides it.*" (Kassotakis & Flouris [5])

Motives are the fundamental modulators of behavior and evidently the main factors of learning. Education is a permanent and constantly evolving procedure of "influencing" the ways of teaching and learning (through the interactive relationship between the teacher and the student) aiming to the best possible result.

In a previous research, we studied the characteristics of students who participate in international mathematical competitions. These characteristics are their preference in courses of mathematics or in related (to mathematics) subjects, their preference to participate in mathematical competitions, mainly organized outside of school and the strong encouragement that they receive by their parents and professors, who play an important role in their whole effort. In addition, the above characteristics include the students' increased self-confidence in mathematics as well as their proud of being distinguished in mathematical competitions (Dimakos, Tyrlis & Ferentinos [2]).

In this research, we try to study how the students (as a social group) are influenced by factors which might motivate them to do mathematics in a level higher than the usual level arising from the standard syllabus.

One of the most important factors that influences students to do mathematics are mathematical competitions. Thus, it is necessary to mention (and analyze) some points for the organization of these competitions. Under the responsibility of the Hellenic Mathematical Society (HMS) three national mathematical competitions take place every year, which bear the name of great ancient mathematicians. To the successful (generally acknowledged) organization of these competitions (beside HMS) many mathematicians of secondary education as well as the Ministry of Education (technical infrastructures) contribute.

The first competition under the name "Thales" takes place (usually) towards the end of October. Any student from all over the country attending Lyceum and second and third Gymnasium grade can participate in this competition. Every student who wants to participate in this competition has to inform the school principal before the deadline of submission, indicated in the instructions edited by the Department of Secondary Education. The HMS Competition Committee prepares and edits different subjects for every grade. As "syllabus" for the competition and for every grade is the curriculum of the previous grades according to the syllabus of Pedagogical Institute concerning Mathematics. It is remarkable that the last years about 12000 students participated in the competition "Thales".

After the marking of the papers the HMS Competition Committee announces the list of those who have succeeded. This list contains (for ever grade) the names of the students whose mark is higher or equal to the basis which is formed. This base is formulated relatively to the difficulty degree of the questions and the specific number of the students who has to pass to the next level. The students who have passed "Thales" (about 2500 students) have the right to participate in the second competition.

The second competition is called "Eukleides" and takes place during the second half of January. The questions are different for every grade. With the same procedure the list of students (it consists of about 300 students), who will participate in the third and last competition, the National Mathematical Olympiad "Archimedes", is announced.

Purpose of the study

The purpose of this particular work is to study and analyze the factors which influence students to do mathematics, aiming to apply to the education methods and practices that enhance, promote and encourage the positive attitude of students towards Mathematics.

Methodology

Subjects of research-procedure

In this research three hundred and thirty nine children from High Schools and Junior High schools from all over the country participated, who competed in the 25th National Mathematical Olympiad "Archimedes". Out of those students, 247 (72,9% percentage) were boys and 92 (27,1% percentage) were girls. The children were students of the 2nd and 3rd grade of Junior High school, 1st, 2nd and 3rd grade of High school.

Tools of measurement

The students were given a questionnaire with 7 closed questions asking for the following information: (1) socio-demographic characteristics, (2) school marks from the previous grade in mathematics and in all courses (general average) respectively, (3) grade that student attends, and (4) educational attainment and professions of their father and mother.

Finally, in the last part of the questionnaire students are asked to report the degree of their influence by the 12 factors, expressing it by using a five level scale of Likert type (Minimum=1, Little=2, Medium=3, Much=4, Very Much=5).

Results

Descriptive Examination

Table 1 below presents the distribution of the boys and girls per grade.

	2nd JHS	4rdJHS	1stHS	2ndHS	3rdHS	Total
	f(%)	f(%)	f(%)	f(%)	f(%)	f(%)
Boys	54 (67.5)	67 (72)	41 (69.5)	38 (73.1)	47 (85.5)	247 (72.9)
Girls	26 (32.5)	26 (28)	18 (30.5)	14 (26.9)	8 (14.5)	92 (27.1)
Total	80	93	59	52	55	339

Table 1

In what follows, we shall refer to the descriptive results concerning questions 2–7.

Question 2. "Which were your marks in mathematics at the previous grades?"

In this question the students mention the final average which was formed from the final written exam in mathematics at the former grades. For the High School grades in separate columns the marks in Algebra, Geometry and Mathematics (2nd grade) are reported.

Studying the answers we can notice the high scores of the students in mathematics (95% of the students have got an average score of 19 and 20). This fact is due to the intense interest that the students show for mathematics, beyond the strict frame of the school syllabus.

Question 3. "Which was your average to the former grades?"

In this question students report the final average in all courses. The high scores (about 95%) in score scale from 18 to 20, show the particular good relationship of the students with the study and comprehension of all the courses (regardless their high scores in mathematics).

Question 4. "Which grade are you?"

The results of this question are reported in Table 1 together with the sharing of students' sex.

Question 5. "Which is the educational status of your mother and father?"

In this question the students had to give answers about the educational status of their father and mother, choosing among five study levels. In the results showed to the tables below, level 1 (primary school) and level 2 (Junior High school) are put together, because only one parent appeared with education of level 1. It has also become clear that there is a predominance of parents who possess a university degree (85,2% for the father and 84,9% for the mother).

	Frequency	Rel. frequency
Primary/Junior	11	3.3
High school	39	11.5
University	173	51.2
Postgraduate	115	34.0
Total	338	100

Table 2. Father's educational status

Question 6. "Which is the profession of your father and mother?"

In this question the students had to give answers about the profession of their father and mother freely (without preselected answers). The different professions were classified taking under consideration the relation degree with mathematics and education in general. We created this way the following categories:

	Frequency	Rel. frequency
Primary/Junior	9	2.7
High school	42	12.4
University	194	57.4
Postgraduate	93	27.5
Total	338	100

Table 3. Mother's educational status

Category 1: Mathematician

Category 2: Teacher (in this category teachers of other disciplines are included).

Category 3: Engineer (Engineers of Technical University are included of any specialty).

Category 4: Economist (in this category Economists and graduates of economic schools are included).

Category 5: Miscellaneous level 4+ (in this category we include professions were at least a university degree is necessary, for example Doctor, Pharmacist, Lawyer etc).

Category 6: Miscellaneous level 3- (in this category we include professions were a university degree is not necessary, for example Farmer, Goldsmith, Fireman etc).

Especially for the women (mothers) professions another category was added, "Housewife". This addition has been made in order to examine statistically, if and to what extent the presence of the mother in the house could influence the students to do mathematics, or their studies in general.

The results of the classification we described above are presented at the tables below.

	Frequency	Rel. frequency
Mathematician	28	8.3
Teacher	60	17.8
Engineer	72	21.4
Economist	16	4.7
Misc. level 4+	113	33.5
Misc. level 3-	48	14.2
Total	337	100

Table 4. Father's profession

	Frequency	Rel. frequency
Mathematician	20	5.9
Teacher	108	32.0
Engineer	26	7.7
Economist	9	2.7
Misc. level 4+	108	32.0
Misc. level 3-	24	7.1
Housewife	42	12.5
Total	337	100

Table 5. Mother's profession

QUESTION 7: "Select the degree different factors influenced you to do Mathematics, putting the symbol $\surd$ or x in the appropriate box."

We shall call the factors that we mention in this question "causes of influence", in order to avoid confusion with the factors we are going to extract right below with the Factor Analysis Method and which (factors) are groupings of the initial factors (causes of influence) in wider groups.

Applying the Descriptive examination to the 12 factors of question 7,the following table was derived, which contains the influence percentages (much up to very much), relatively to the influence degree of the students that corresponds to each one of the causes of influence. We notice that the biggest is the influence of Mathematical Competitions and the least of the Media.

Causes of influence	Influence percentage (%)
Mathematical competitions	61.95
Father	45.72
Other books	34.81
School teachers	31.27
Publications of the HMS	26.55
Mother	26.25
Teacher out of school	24.78
Close family environment	23.01
Internet	18.88
Friends–colleagues	17.11
School books	12.98
Media	2.36

Table 6.

Factor Analysis

Factor Analysis is a statistic method intending to determine new questions, that we call factors. Factors explain the relationship between the initial questions through their grouping in groups smaller than the initial. The classic method of factor analysis which we are going to apply to our sample is the Exploratory Factor Analysis with Varimax rotation (SPSS [8]). Before we present the conclusions from Factor Analysis we are going to make a reference to some criteria that must be fulfilled in order to have by this method reliable result.

First of the criteria is the rate of the index that characterizes the good adaptation to the Factor Analysis according to the scale of Kaiser-Meyer-Olkin (KMO); it must be from 0.6 to 1, because, according Kaiser [4], rate less than 0.6 is considered medium, rate 0.5 awful, while rates smaller than 0.5 are considered unacceptable.

The second criterion is the table, that shows the correlation per two of all the questions, not to be diagonal (diagonal terms one point, the rest zero), because in this case there is no correlation. In order to check the zero hypotheses, according to which the correlation table is diagonal, that is there is no correlation between the variables, we use the Bartlett test. If the level of importance (sig) is small enough (< 0.05), then we reject the zero hypotheses and we accept the alternative hypotheses which states that there is correlation among at least two of the variables.

The third criterion is the suitable size of the sample. According to Gorsuch's opinion [3], at least five persons must correspond to every variable and the minimum size of the sample should be 200 persons.

While examining the above criteria we realized that all the conditions that insure the application of Factor Analysis are completely fulfilled. The KMO index in particular takes the value 0.701, so according to Kaiser [4] its value is very good, the Bartlett Test's level of importance is < 0.001, so we reject the hypothesis that the correlation table is diagonal. The sample consists of 339 persons.

From the application of Factor Analysis with Varimax rotation, 4 factors were derived with eigenvalue bigger than one, which explains the 55.948% of the total variance, an especially satisfactory percentage (Table 7).

In the next table (Table 8) we present the questions which contain all factors with the corresponding loading, which are particularly important since they are all bigger 0,60.

Factors' description

The first factor is specified by the students' aspects, who state that the factor which influenced them more to do mathematics is composed by the publications of the Hellenic Mathematical Society, books, internet, mathematical competitions and media. We could possibly name it "influence not by persons but through procedures outside school". It explains the 20.366% of the total sharing and its eigenvalue is 2.444.

The second factor is specified by the students' aspects, who state that the factor which influenced them more to do mathematics is composed by teachers outside school, friends-colleagues and persons of the close family environment. We

	Initial eigenvalues			Rotation sums of squares loadings		
Comp.	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.904	24.201	24.201	2.444	20.366	20.366
2	1.430	11.913	36.114	1.546	12.882	33.248
3	1.256	10.466	46.581	1.410	11.751	44.999
4	1.124	9.367	55.948	1.314	10.949	55.498
5	.972	8.102	64.050			
6	.839	6.988	71.038			
7	.767	6.393	77.431			
8	.670	5.585	83.016			
9	.608	5.065	88.081			
10	.527	4.389	92.470			
11	.471	3.925	96.395			
12	.433	3.605	100.000			

Extraction method: Principal component analysis

Table 7. Total variance explained

	Component			
	1	2	3	4
Father's influence				.791
Mother's influence				.742
School teachers			.884	
Other teachers		.664		
Textbooks			.606	
Editions by HMS	.736			
Other editions	.754			
Internet	.714			
Friends–Schoolmates		.648		
Close family members		.732		
Mathematical competitions	.643			
Means of mass communications	.452			

Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization

a Rotation converged in 5 iterations

Table 8. Rotated component matrix

could possibly name it: "influence by the direct social environment". It explains the 12.882% of the total sharing and its eigen value is 1.546.

The third factor is specified by the students' aspects, who state that the factor which influenced them more to do mathematics is composed by their school teachers and school books. We could possibly name it: "influence by school". It explains the 11.751% of the total sharing and its eigenvalue is 1.410.

The fourth factor is specified by the students' aspects, who state that the factor which influenced them more to do mathematics is composed by their father's and mother's influence. We could possibly name it: "influence by the parents". It explains the 10.949% of the total sharing and its eigenvalue is 1.314.

The internal credibility factor, alpha of Cronbach, for the first factor is 0.72, for the second is 0.70, for the third is 0.65 and for the fourth factor is 0.50. The values of internal reliability factor are according to Aiken [1] satisfactory with the exception of the value that corresponds to the fourth factor which is below 0,60 and consists mediocre credibility, therefore any conclusion derived from that factor should be considered cautiously.

Conclusions

The results of this investigation showed that procedures with social base and extensions urge students to do mathematics in a level higher than the usual. This study also showed that Mathematical Competitions (through the Olympic spirit and without making victory an end in itself) are beneficial to students doing mathematics. In addition, they proved to be the starting point for the detection of gifted students (in mathematics) as well as the springboard for their further development. Within that context, the Hellenic Mathematical Society, through the organization of mathematical competitions and its publications can be considered as an important factor of students' influence.

Proposals

Based on the above conclusions we could formulate proposals aiming to enhance the factors which influence students to do mathematics. First, we suggest that there must be emotional and scientific support to students in order to participate in mathematical competitions. Then, we suggest that teachers (inside and outside school) and the entire social background should support and encourage students to participate in mathematical competitions (regardless of their performance and the final results). Moreover, we think that the success of the students who participate in mathematical competitions should be acknowledged and showed off. As far as the students who participate in competitions are concerned, they should "be used" for creative expression and exchange of opinions which exceed the "narrow" frame of school books during the lesson (in schools). In addition, we propose that during the school hours, sometimes (when the teacher estimates that the conditions are suitable), mathematical problems given at mathematical competitions should be solved (with the assistance of students experienced in mathematical competitions), for which no special theoretical mathematical background is necessary.

Finally, we argue that the Hellenic Mathematical Society must be further supported (since it is the only institution out of school that organizes such competitions) in its efforts to improve the quality of its competitions.

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APPENDIX: QUESTIONNAIRE "ARCHIMEDES 2008"

1) **BOY** ☐ **GIRL** ☐

2) Which were your marks in mathematics at the previous grades?

A JUNIOR HIGH SCHOOL	.....	B JUNIOR HIGH SCHOOL	...	C JUNIOR HIGH SCHOOL	...

A HIGH SCHOOL	ALGEBRA	.....	B HIGH SCHOOL	ALGEBRA	...
	GEOMETRY	.....		GEOMETRY	...
				ΚΑΤΕΥΘΥΝΣΗ	...

3) Which was your average to the former grades?"

A JUNIOR HIGH SCHOOL	B JUNIOR HIGH SCHOOL	C JUNIOR HIGH SCHOOL	A HIGH SCHOOL	B HIGH SCHOOL

4) Which grade are you?

B JUNIOR HIGH SCHOOL ☐ **C JUNIOR HIGH SCHOOL** ☐ **A HIGH SCHOOL** ☐
HIGH SCHOOL ☐ **C HIGH SCHOOL** ☐

5) Which is the educational status of your mother and father?

EDUCATIONAL STATUS	POSTGRADUATE	UNIVERSITY	HIGH SCHOOL	JUNIOR HIGH SCHOOL	PRIMARY
FATHER:					
MOTHER:					

6) Which is the profession of your father and mother?

	PROFESSION
FATHER:	
MOTHER:	

7) Select the degree different factors influenced you to do Mathematics, putting the symbol "✓ or x in the appropriate box

FACTORS THAT INFLUENCED YOU TO DO MATHEMATICS	VERY LITTLE	LITTLE	MEDIUM	MUCH	VERY MUCH
FATHER					
MOTHER:					
TEACHERS SCHOOL:					
TEACHERS OUTSIDE SCHOOL:					
SCHOOL BOOKS:					
PUBLICATIONS OF THE HELLENIC MATHEMATICAL SOCIETY (HMS):					
OTHER BOOKS (EXCEPT PUBLICATIONS OF THE HELLENIC MATHEMATICAL SOCIETY):					
INTERNET:					
FRIENDS - COLLEAGUES:					
CLOSE FAMILY ENVIRONMENT :					
MATHEMATICAL COMPETITIONS:					
MEDIA:					