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Study on the Impact of Attitude, Motivation, and Study Time on Mathematics Performance in Secondary School Students

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Abstract: *This study explores secondary school students' perspectives on mathematics, presenting findings from quantitative research conducted at an elite Romanian school. Through an online questionnaire, the study investigates the complex relationship between academic performance in mathematics and key variables, such as the hierarchical placement of mathematics in students' preferences, motivation for learning, parental influences, involvement in homework, allocation of study time, and factors that increase interest. The survey, devoid of invalid responses, emphasizes the robustness of the data collection process. The research highlights the existence of a small number of quantitative studies on the assumed topic and aims to provide useful data in improving educational processes by clarifying some links between these variables and mathematics performance. The research data show a strong link between the time allocated to study and mathematics results, but very good results are obtained only by those who allocate more than two hours of study per day to this subject. The data are also statistically significant for the relationship between the time students believe they would dedicate to studying mathematics if it were not an exam subject and their current average in mathematics. The potential impact considers the possibility of leveraging the data and developing research to develop new improved teaching strategies, educational policies and targeted support for students.*

Keywords: *mathematics, school results, motivation, study time.*

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Introduction

Recent research has emphasized the importance of mathematical skills in everyday life, in the personal development of students, and in the formation of critical or abstract thinking skills. However, many students have shown that they do not perceive this aspect and tend to disregard mathematics, which they classify as a simple subject that raises learning difficulties (Muwonge et al., 2018). Among the difficulties identified by education experts, the emotional factor plays a key role (Hernández de la Hera et al., 2023). Studies have shown the existence of a significant correlation between educational outcomes and students' attitude towards learning, analyzing factors that significantly influence school performance (Ker et al., 2023; Samuelsson, 2023). Also, anxiety and stereotypes have a significant impact on educational success. Reducing the anxiety associated with the study of mathematics and working with stereotypes of students and their families, including those based on gender (Ardura et al., 2023), contributes significantly to increasing students' interest in this discipline and improving school performance, including in other educational subjects (Abín et al., 2020).

A determining factor in school success in mathematics is motivation for learning (Robas et al., 2020), analyzed in relation to different learning contexts and levels of schooling (Alipour et al., 2023). Intrinsic motivation has been considered a key factor for the active involvement of students in the learning process and the achievement of school performance (Ryan et al., 2022), which are related, including in mathematics, to the level of involvement in learning, with a special note for the perspective of task-centered learning (Suárez et al., 2019). Education of motivation for learning is also an important opportunity in the effort of education systems to reduce school failure and dropout. However, current trends show a decrease in motivation for the study of mathematics, especially at the level of secondary school (Chouinard & Roy, 2008; Niemivirta et al., 2023).

Despite efforts to make teaching attractive, there has been an increase in students' negative attitude towards learning since primary and secondary school (Aguilar, 2021). Although the key term in this problem seemed to be "understanding" notions, the problem is a complex one. Research has suggested that the transition to innovative, practical learning methods can improve students' performance in mathematics. It has also highlighted the implications of allocating the number of study hours for mathematics in primary and secondary schools and their relationship with the low interest of students towards training in certain scientific fields (De la

Peña et al., 2021). The attitude of students towards learning in mathematics is influenced by maturation, the proximity of high school entrance assessments or exams and the attitude of parents towards this discipline, especially mothers (Galende et al., 2020). This attitude is essential for applying mathematical knowledge in real life and for maintaining interest in this discipline (Wakhata et al., 2022). Complementary, the link between the attitude towards mathematics and the school performance indicators has been investigated (Damrongpanit, 2019), arguing that the positive attitude is a critical variable in the learning process (Geary, 1996; Zamir et al., 2022). Studies on the differences in attitude according to the class of students are still in the beginning (Galende et al., 2020).

Low levels of math performance have been associated with lack of confidence, negative emotional involvement, and passive behavioral attitudes (Li et al., 2021). In addition, there is low confidence in the use of technology in mathematics education (Barkatsas et al., 2009). Studies have also shown that anxiety management and the development of cognitive and motivational skills have a positive impact on school results, especially in mathematics (Abín et al., 2020; Ashcraft et al., 2009). Another important factor is the didactic communication style of the teacher. In this respect, didactic approaches based on student-centered learning and critical thinking development are essential. Key thinking skills have been associated with the ability to operate in different training and practical contexts with abstract notions such as those of mathematics. Complementarily, self-efficacy has been identified as a factor that positively influences the attitude towards learning mathematics. Its complex role has been analyzed in connection with the development of scientific reasoning and attitudes towards science and learning. Performance in mathematics is influenced by demographic, non-cognitive and personality factors, and also by the efficiency of the teaching process (Gjicali & Lipnevich, 2021).

Given the difficulties and particularities of mathematics teaching at different ages, the literature has addressed the possibilities of reconsideration through different types of research of theories on mathematics teaching. In the context of global educational reforms, educational systems have become increasingly concerned with the constant increase in the quality of the teaching process, in which special attention has been paid to the teaching of mathematics. Thus, the teacher's teaching style, the strategies used and the school's policy are determining factors for the effectiveness of mathematics lessons (Li et al., 2016) and for supporting learning both in and outside the school. The impact of teacher knowledge on student performance has highlighted the need for revised education policies (Hill et al., 2005). The

skills of understanding and operating with mathematical notions depend to a large extent on the didactic strategies used by the teacher in the classroom and on the development of the capacity for representation in students (Minarni et al., 2016). Learning through problem solving supports the understanding of the practical utility of the studied notions, but research has shown that there is a need for new didactic strategies for teaching mathematics, in order to better harness the motivations (Hossein-Mohand & Hossein-Mohand, 2023) and the mathematical and general learning abilities of students.

The use of intelligent technologies in the teaching of mathematics have brought significant benefits, favoring the psychological balance of students and improving their motivation for learning, thus supporting sustainable education (Mitsea et al., 2024). In this context, studies have shown that the implementation of the use of mobile technologies influences both the success and motivation of students for learning mathematics. Research has also highlighted the beneficial impact of the use of mobile technologies in diverse learning environments (Poçan et al., 2023) and in extracurricular contexts. Students appreciate the use of specialized programs and educational games in learning mathematics, but their parents prefer the traditional approach to teaching, for the role of personal communication and socialization in learning stages (Yong et al., 2016). Also, the use of manipulative, interactive and immersive tools, such as those for virtual reality or augmented reality, and digital platforms can support the understanding of abstract concepts (Thomsen, 2023), provided that teachers are well trained and motivated to implement and use them (Carbonneau et al., 2018; Yang et al., 2024; Jatisunda et al., 2024).

In the context of the need to identify new didactic strategies in mathematics teaching, research has shown different possibilities of less classical approach of this discipline (Molina-Cuasapaz et al., 2022), with significant results including on social interactions. In order to increase the performance in mathematics, the effectiveness of the STEM approach in different training environments has been investigated in different researches (Alvidrez et al., 2024), but the data showed that the use of such learning strategies was not accompanied by a corresponding appreciation on the part of 14-15 year olds.

Although there are significant differences between countries (Xu, 2023), student self-employment (Fan et al., 2017; Fernández-Alonso et al., 2015) remains a reality in all education systems, in connection with the constant increase in school results. The context of the development of social networks, the use of learning platforms by teachers and schools has made

homework more and more done by students in the online space (Doorn et al., 2010). These homework-solving contexts prove useful insofar as the feedback students receive is immediate and the interaction with online learning programs is friendly to them and suggests peer-to-peer activity. Differences between schools in terms of time spent by students for learning mathematics, time spent at home for solving homework, the role of family support (Kikas et al., 2022) are studied from the perspective of differences between educational models (Phelps et al., 2012). The big variation of number of hours allocated to the study of mathematics at school and at home requires a further analysis from the perspective of schools ensuring equity in education.

Methodology

Research Aim

Our research was based on the context in which there are few studies especially in Romania, but also internationally, that address the link between motivations on school results in mathematics in secondary school students. The study aims to provide the scientific community and education systems with data that will contribute to a better understanding of the links between individual study time, learning motivation, preference for mathematics and school results in this discipline of students in the upper secondary education. The study also aims to provide data that will positively assist students in learning, their families in supporting them effectively and consistently in the math learning effort. Our investigation is constituted in a preliminary research and aims to provide stable data for a further development of the investigative approach in diverse educational and socio-cultural spaces.

Research objectives

The research was guided by the following questions: Is there a strong link between the preference for mathematics of students in the second part of secondary education and the results they have in this discipline of study? Are there significant differences between the motivation of learning in mathematics and the results in this educational discipline? Is there a threshold for students at the end of secondary school from which the period of individual study leads to obtaining very good results in mathematics? Does the number of hours allocated to individual study in mathematics by secondary school students depend on the importance of the discipline for their admission to high school?

Participants

Students in Grades 7 (two classes) and 8 (two classes), aged 13-15, from the "Sf. Simion Ştefan" Orthodox Theological Seminary of Alba Iulia (Romania), were invited to answer the survey items. The school was selected based on the notable results that its students had in recent years at the national end of secondary school assessments, but also for the good reputation it has in the educational space in terms of school-family educational partnership, able to facilitate a good student – family educational dialogue, targeted by our research approach. For the research team, it mattered a lot that about 85% of the students in the four selected classes received parental consent to participate in the survey, which made us receive answers from respondents with different school results, motivations for learning and personal aspirations.

The survey was conducted online, the link of the form was posted on the social-media groups of students in the classes included in the research. The parents of these students were notified by the school about the survey, received in writing the information on the intention of the research, details on the collection, analysis and interpretation of the data and were invited to express in writing their consent for the participation of their children in the research. The school at which the research was conducted gave its consent to this scientific endeavor, following the analysis of the documents submitted by the research team. At all stages, anonymity was guaranteed and ensured, participants were not promised and no reward was offered for participating in the survey. There were no cases of explicit refusal of parents related to their children's participation in the research, but not all students in the classes involved responded to the questionnaire items.

The data were accepted in the first part of the 2023-2024 school year, and at the end of the mentioned period, 89 responses were recorded, representing 84.76% of the total students in the four classes included in the research. The distribution of respondents by class is 56.2% seventh graders and 43.8% eighth graders. This quantitative study was based on closed questions, through a Google Forms form, so we did not record incomplete answers. In this study we included the analysis and interpretation of the data from the second part of the questionnaire applied by the research team, the last four items, the first part was included in a previous study (Opris & Opris, 2024).

Data analysis

The data was analyzed using the SPSS statistical package (version 22.0; SPSS, Inc., USA). The data analysis was carried out with the help of value indicators or basic statistics such as number, percentage, average and statistical analyses were carried out.

In the first item, the data were analyzed with the Jonckheere - Terpstra J test (to observe the relationship between the increase in the preference for mathematics and the increase in the average in mathematics), with the Mann-Whitney test (to analyze the differences between pairs of variables, considered independent samples), the effect size and the mean ranks were calculated.

For the data from the second item, the Kruskal-Wallis H test was used (for analyses such as the relationship between mathematical results and learning motivations), the Mann-Whitney U test (for the analysis of differences between pairs of variables, considered independent samples), the mean ranks and the magnitude of the effect r were calculated.

For the data from item three we used the method of Anova One-Way variance analysis (to verify the relationship between the study time in mathematics and the average in this discipline), the post hoc Hochberg GT2 test (to check the differences between the groups of respondents, for the relationship between the study time and the average in mathematics) and the magnitude of the effect r.

The data from item four were analyzed with the Mann-Whitney U test (for the comparative analysis of the time allocated to the study in mathematics between the two classes participating in the study), the Wilcoxon test (for the comparison of two paired variables: the time dedicated to the study of mathematics, respectively the anticipated study time if mathematics were not an exam discipline), the mean ranks, the magnitude of the effect r were calculated, the ANOVA One-Way variance analysis was realized (for the analysis of the students' anticipated study time and their average in mathematics) and the post hoc Hochberg GT2 test was used (to check the differences between the groups of respondents, for the relationship between the anticipated study time and the average in mathematics).

Results

The place of the mathematics discipline in students' preferences

One of the items of the questionnaire asked the students to mention their favourite educational subject. Starting from the fact that mathematics supports all disciplines in the curricular areas "Mathematics and Natural

Sciences", respectively "Technologies", in Table 1 we made the following codifications: 1 – disciplines epistemologically distant from mathematics, 2 – disciplines epistemologically close to mathematics, 3 – mathematics.

Table 1. Favourite discipline: 1 – disciplines epistemologically distant from mathematics; 2 – disciplines epistemologically close to mathematics; 3-mathematics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	55	61.8	61.8	61.8
	2.00	19	21.3	21.3	83.1
	3.00	15	16.9	16.9	100.0
	Total	89	100.0	100.0	

The data from Table 1 show that, out of the total students surveyed, 16.9% placed mathematics first in the hierarchy of choices made by them, a percentage very close to that of students with average 10 in mathematics (18%). We also find a percentage of 21.3% of the surveyed students, who chose subjects close to mathematics from an epistemological point of view, in particular: Computer Science, Physics, Chemistry. The majority of students, at a percentage of 61.8%, chose other subjects.

We also sought to find out the relationship between the preference for this educational discipline and the average obtained by students in mathematics, both through analytical and statistical analyses. The data were listed in Table 2.

Table 2. Average in mathematics according to preference for different disciplines

			Preference for disciplines (D)			Total
			1	2	3	
Average in mathematics	5.00	Count	7	0	0	7
		% of D	12,7%	0,0%	0,0%	7,9%
	6.00	Count	10	0	0	10
		% of D	18,2%	0,0%	0,0%	11,2%
	7.00	Count	10	4	0	14
		% of D	18,2%	21,1%	0,0%	15,7%
	8.00	Count	13	8	2	23
		% of D	23,6%	42,1%	13,3%	25,8%
	9.00	Count	9	7	3	19
		% D	16,4%	36,8%	20,0%	21,3%
	10.00	Count	6	0	10	16
		% of D	10,9%	0,0%	66,7%	18,0%
Total		Count	55	19	15	89
		% of D	100,0%	100,0%	100,0%	100,0%

The data from Table 2 show that for students who prefer subjects epistemologically distant from mathematics (column 1), we find students with different averages, the maximum value being 23.6% for average 8, and the minimum value 10.9% for average 10. Students who prefer subjects epistemologically close to mathematics (column 2) have averages between 7 and 9, with the highest percentage value being recorded for average 8, i.e. 42.1%. If we analyze the averages of students who prefer mathematics and the percentage for each average (column 3), we notice an increase in the percentage from the average 8 (13.2%), to the average 10 (66.7%).

The data in Table 2 led us to statistical analysis. Since the dependent variable is quantitative (math average) and the independent variable is ordinal, we used the Jonckheere-Terpstra J test for directional analysis, specifically to see if increasing students' preference for math has the effect of increasing the math average. The data are listed in Table 3.

Table 3. Jonckheere-Terpstra Testa

	Average in mathematics
Number of Levels in Favourite Discipline 1: not related to mathematics; 2: related to mathematics; 3: mathematics	3
N	89
Observed J-T Statistics	1640.500
Mean J-T Statistic	1077.500
Std. Deviation of J-T Statistic	119.492
Std. J-T Statistic	4.712
Asymp. Sig. (2-tailed)	,000
a. Grouping Variable: Favorite Discipline 1: disciplines epistemologically distant to mathematics; 2: disciplines epistemologically close to mathematics; 3: mathematics	

From the Jonckheere-Terpstra test Table, we observe that the value of the J-T test is J = 1640.5, and the standardized value of the J test is z = 4.712, at p = 0.000 (p < 0.05). The positive value of z indicates a directly proportional relationship between the increase in preference for mathematics and the increase in the average in mathematics. The calculated effect size is r = 0.50, a strong level effect, according to Cohen.

$$r = \sqrt{\frac{z^2}{n}} = \frac{z}{\sqrt{n}} = \frac{4{,}712}{\sqrt{89}} = 0{,}50$$

Since through the above relationship we have obtained a general effect, we will apply the Mann-Whitney test, which allows analyzing the pair comparisons and calculating the size of the effect for the results in this test.

As the "favourite disciplines" variable has three levels, we will realize three pair comparisons, in terms of the threshold for significance is corrected for the number of comparisons by the Bonferroni method: $\alpha = p/3$, $\alpha = 0{,}016$.

For the first comparison, between pairs 1-2, respectively disciplines epistemologically distant from mathematics versus subjects epistemologically close to mathematics, we obtained U = 377.5, z = -1.834, n = 74, p = 0.067, ($p > 0.016$), and the magnitude of the effect, calculated by the above formula is:

$$r1 = \frac{1{,}834}{\sqrt{74}} = 0{,}21$$

For the second comparison, between pairs 1-3, respectively disciplines epistemologically distant from mathematics versus preference for mathematics, we got U = 104.5, z = -4.484, n = 70, p = 0.000, ($p < 0.016$), and the magnitude of the effect is:

$$r2 = \frac{4{,}484}{\sqrt{70}} = 0{,}54$$

For the third comparison, between pairs 2-3, respectively disciplines epistemologically close to mathematics versus preference for mathematics, we got U = 32.5, z = -3.972, n = 34, p = 0.000, ($p < 0.016$), and the magnitude of the effect is:

$$r3 = \frac{3{,}972}{\sqrt{34}} = 0{,}68$$

The results obtained were summarized in Table 4, in which, in addition to the size of the effect, we also specified the ranks for each category of the three analyzed pairs.

Table 4. Mean Rank and effect size for pair comparisons, in relation to preferred subjects-average in mathematics

Curr. No.	The pair	U	Mean Rank	|z|	N	p 0.016	R	Effect size
1.	1 - disciplines epistemologically distant from mathematics 2- disciplines epistemologically close to mathematics	377.5	34.86 45.13	1.834	74	0.067	0.21	weak
2.	1 - disciplines epistemologically distant from mathematics 3-preference for mathematics	104.5	29.90 56.03	4.484	70	0.000	0.54	strong
3.	2- disciplines epistemologically close to mathematics 3-preference for mathematics	32.5	11.71 24.83	3.972	34	0.000	0.68	strong

The data show that there is a significant upward trend in performance; the higher the students' preference for the math discipline, the higher the average for this educational discipline. The Mann-Whitney U test showed us that there are significant differences for two of the pair comparisons (we took into account the adjusted significance threshold), namely, the preference for mathematics compared to the preference for epistemologically distant disciplines (r = 0.54), respectively the preference for mathematics and the preference for epistemologically close disciplines (r = 0.68), observable also by comparing the averages of ranks for each pair, positive differences in favour of the preference for mathematics. In the case of the first pair there are no statistically significant differences in the choice of subjects other than mathematics (epistemologically close or distant) and the average in this educational discipline.

School results in mathematics and students' motivation for learning in mathematics

In educational policy documents (Ministry of National Education and Scientific Research, 2017), mathematical competence also refers to the development of mathematical thinking, observable in students with good results in the ability to solve various problems in everyday situations. In our research we wanted to see if this fact is also found in the respondents' results, as motivation for learning mathematics. An item of the questionnaire asked the students to choose the main motivation for learning mathematics, from a list proposed by us, which contains two internal motivations (3: positive and 2: negative) and two external motivations (1: positive and 4: negative). In Table 5 we summarized the results in the order in which these motivations were entered in the questionnaire, which are also constituted in encodings of motivations in the analyzes made.

Table 5. Motivation of learning in mathematics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. Mathematics organizes my logical thinking	31	34.8	34.8	34.8
	2. I notice that I have results, even if I allocate more time for learning	19	21.3	21.3	56.2
	3. I'm learning math because I like it	11	12.4	12.4	68.5
	4. My parents are unhappy if I get a low grade in math	28	31.5	31.5	100.0
	Total	89	100.0	100.0	

The data from Table 5 lead to the conclusion that two thirds of students are based on external motivations for learning: "Mathematics organizes my logical thinking" (34.8%), respectively "My parents are unhappy if I get a low grade in mathematics" (31.5%). Obtaining good results from the study (21.3%) and learning for pleasure (12.4%) are less preferred motivations by students.

The relation between average in mathematics – motivation for learning in this discipline can be analyzed based on the data in Table 6.

Table 6. Average in mathematics * Crosstabulation motivation

% within Motivation						
		Motivation				Total
		1.00	2.00	3.00	4.00	
Average in mathematics	5.00	6,5%			17,9%	7,9%
	6.00	12,9%			21,4%	11,2%
	7.00	3,2%	26,3%		28,6%	15,7%
	8.00	22,6%	42,1%	45,5%	10,7%	25,8%
	9.00	25,8%	21,1%	36,4%	10,7%	21,3%
	10.00	29,0%	10,5%	18,2%	10,7%	18,0%
Total		100,0%	100,0%	100,0%	100,0%	100,0%

Based on the data in Table 6, we can make the following observations: students who chose as motivation the role of mathematics in organizing logical thinking are found in different percentages on all six values of averages, but the majority (77.4%) have averages above eight. The highest percentage value (29%) corresponds to students with an average of 10 in mathematics.

If we refer to the second motivation, "I notice that I have results, even if I allocate more time for learning" the data show that it was chosen only by students with averages in the range 7-10, the highest percentage value (42.1%) being recorded in students with average 8 in mathematics.

The motivation related to the preference for this educational discipline "I learn in mathematics because I like it" was chosen only by students with high averages, more than half of the students (54.6%) have averages of 9 and 10.

Parents' dissatisfaction with poor results can be found as motivation in students regardless of the average, but over two thirds of the students who chose this answer variant have averages between 5-7, the highest value (28.6%) being recorded in students with average 7 in mathematics.

We intended to carry out a statistical analysis, in which to trace the existence of a relationship between the results in mathematics (VD, quantitative, without normal distribution) and the motivations of learning (VI, categorical), through the Kruskal-Wallis H nonparametric test, for independent samples, which is based on rank analysis and data hierarchy.

The output in Table 7, Ranks, shows the number of subjects who chose each learning motivation and the mean ranks, and Table 8, the value of the Kruskal-Wallis H test.

Table 7. Ranks

	Motivation	N	Mean Rank
Average in mathematics	1.00	31	52.55
	2.00	19	46.61
	3.00	11	57.64
	4.00	28	30.59
	Total	89	

Table 8. Test Statistics a,b

	Average in mathematics
Chi-Square	14.625
df	3
Asymp. Sig.	,002
a. Kruskal Wallis Test	
b. Variable Grouping: Motivation	

The highest mean ranks, respectively the best results are obtained in the students who chose as motivation the pleasure learning in mathematics (MR3 = 57.64), followed by the mean for the quality of mathematics to develop logical thinking (MR1 = 52,55). The motivation related to the observation of the effects of learning (MR2 = 46.61) follows, and finally negative external motivation, dissatisfaction of parents for low results (MR4 = 30,59). The value of the Kruskal-Wallis H Test H ($\chi 2$), H (3) = 14,348, p = 0,003 shows that there are statistically significant differences in the motivation of learning in mathematics and the results in this educational discipline.

As with the application of the Jonckheere-Terpstra test, neither the Kruskal-Wallis H test gives us data on which of the motivations presents significant differences. We can see that there are differences for example between the maximum and minimum values of the means of ranks MR3 and MR4 or between MR3 and MR2, but in order to know between which of the four groups corresponding to the four motivations there are significant differences, we will apply the Mann-Whitney U test and we will adjust the significance threshold for the six pair comparisons that can be made, by the Bonferroni method: $\alpha = p/6$, $\alpha = 0,008$.

Following an algorithm similar to that presented in the previous statistical analyses, we calculated the value of r, based on the data provided through SPSS, for each pair comparison. The results obtained were summarized in Table 9, in which, in addition to the size of the effect, we also specified the ranks for each category of the three analyzed pairs.

Table 9. Mann-Whitney U test value, mean ranks and effect size for pair comparisons

Curr. No.	The pair	U	Mean Rank	|z|	N	p α = 0,008	R	Effect size
1.	1-logical thinking 2-I observe results	241.5	27.21 22.71	1.089	50	0.276	0.15	very weak
2.	1-logical thinking 3-I like it	163.5	21.27 22.14	0.207	42	,836	0.03	nonexistent
3.	1-logical thinking 4-dissatisfaction of parents	246	36.06 23.29	2.897	59	,004	0.37	weak
4.	2-I notice results 3-I like it	258	13.58 18.82	1.662	30	,097	0.30	weak
5.	2-I observe results 4-dissatisfaction of parents	552	30.32 19.71	2.657	47	0.008	0.38	weak
6.	3-I like it 4-dissatisfaction of parents	464.5	28.68 16.59	3.027	39	,002	0.49	strong

The data in Table 9 show that in three of the six pair comparisons, we have statistically significant results, which we will present below.

There are significant differences between motivation 1 ("logical thinking", external, positive) and motivation 4 (external, negative) in terms of effects on performance in mathematics ($U = 246$, $z = 2.987$, $p = 0.004$, $r = 0.37$).

There are significant differences between motivation 2 ("observing results", internal, negative) and motivation 4 ("dissatisfaction parents", external, negative) in terms of effects on performance in mathematics ($U = 552$, $z = 2.657$, $p = 0.008$, $r = 0.38$).

There are significant differences between motivation 3 ("liking it", internal, positive) and motivation 4 ("dissatisfaction parents", external, negative) in terms of effects on performance in mathematics ($U = 464.5$, $z = 3.027$, $p = 0.002$, $r = 0.49$).

We note that in all three situations of pair comparisons in which there are statistically significant differences, motivation 4, a negative external one, has the lowest value of the mean rank. From an educational point of view, this fact shows us the value of internal motivation, but also of positive education. The best results are recorded in internally motivated students.

School results in mathematics and time spent studying mathematics

The effort spent in learning implies a certain time allocated to study in this educational discipline. In our research, we chose five equal time intervals, multiple of 30 minutes, which we encoded in this way, in parenthesis being mentioned the percentage of students according to the chosen study time:

1 - 0-30 minutes (9%)
2 – 30 minutes – 1 hour (9%)
3 – 1 hour-1.50 hours (37.1%)
4 – 1.50 – 2 hours (34.8%)
5 – More than two hours (10.11%)

The results show that 82% of students devote more than one hour a day to the study of mathematics. If we analyze the average in mathematics - study time relationship (see Table 10), we notice an increase in the average with the increase in the number of study hours: the majority of students who learn little (87.5%) have poor results in mathematics (averages of 5 and 6) and the majority of those who allocate more than two hours to learning mathematics (77.8%) have averages of 10. We note that there are also students who allocate between 1.5 hours – 2 hours to the study of mathematics (33.3% and 25.8% respectively) and yet have poor to medium results.

Table 10. Average in mathematics * Study time Crosstabulation

% within Study time							
		Study time					Total
		1.00	2.00	3.00	4.00	5.00	
Average in mathematics	5.00	62,5%	25,0%				7,9%
	6.00	25,0%		12,1%	12,9%		11,2%
	7.00		37,5%	21,2%	12,9%		15,7%
	8.00	12,5%	37,5%	36,4%	22,6%		25,8%
	9.00			15,2%	38,7%	22,2%	21,3%
	10.00			15,2%	12,9%	77,8%	18,0%
Total		100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

To check whether the relationship between the study time and the average in mathematics is statistically significant, we used the method of ANOVA One-Way variance analysis (Tables 11, 12 and 13).

Table 11. Descriptives

Average in mathematics								
	N	Mean	Std. Deviation	Std. Error	95% confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	8	5.6250	1.06066	,37500	4.7383	6.5117	5.00	8.00
2.00	8	6.8750	1.24642	,44068	5.8330	7.9170	5.00	8.00
3.00	33	8.0000	1.22474	,21320	7.5657	8.4343	6.00	10.00
4.00	31	8.2581	1.23741	,22225	7.8042	8.7120	6.00	10.00
5.00	9	9.7778	,44096	,14699	9.4388	10.1167	9.00	10.00
Total	89	7.9551	1.50688	,15973	7.6376	8.2725	5.00	10.00

Table 12. Test of Homogeneity of Variances

Average in mathematics			
Levene Statistics	df1	df2	Sig.
1.693	4	84	,159

From Tables 11 and 12 we note that we have five deeply unequal groups in number, with different averages, but the condition of homogeneity of variances (Levene test $F(4, 84) = 1.693$, $p = 0.159$, $p > 0.05$) is respected, necessary to apply the ANOVA method.

Table 13. ANOVA

Average in mathematics					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	85.579	4	21.395	15.731	,000
Within Groups	114.241	84	1.360		
Total	199.820	88			

The data from Table 13 lead to the conclusion that there are significant differences regarding the average obtained by the students in mathematics and the time allotted for the study: the omnibus F test and the significance threshold from the main ANOVA table have the value $F (4, 84) = 15.731$, $p = 0.00$ ($p < 0.05$). In addition, we note in Table 11 Descriptive that the lowest average ($M = 5.62$) was calculated for students who devote the least time to study (0 – 0.5 hours), and the highest average ($M = 9.77$) for those who learn more than two hours daily.

By means of a post hoc Hochberg GT2 test (applicable for homogeneous dispersions and deeply unequal groups of subjects) we will

find out between which of the groups of students there are significant differences (see Table 14).

Table 14. Multiple Comparisons

Dependent Variable: average in mathematics Hochberg						
(I) Timpstd	(J) Timpstd	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.25000	,58310	,293	-2.9241	,4241
	3.00	-2,37500*	,45958	,000	-3.6945	-1.0555
	4.00	-2,63306*	,46246	,000	-3.9608	-1.3053
	5.00	-4,15278*	,56667	,000	-5.7797	-2.5259
2.00	1.00	1.25000	,58310	,293	-.4241	2.9241
	3.00	-1.12500	,45958	,150	-2.4445	,1945
	4.00	-1,38306*	,46246	,036	-2.7108	-.0553
	5.00	-2,90278*	,56667	,000	-4.5297	-1.2759
3.00	1.00	2,37500*	,45958	,000	1.0555	3.6945
	2.00	1.12500	,45958	,150	-.1945	2.4445
	4.00	-.25806	,29169	,990	-1.0955	,5794
	5.00	-1,77778*	,43855	,001	-3.0369	-.5187
4.00	1.00	2,63306*	,46246	,000	1.3053	3.9608
	2.00	1,38306*	,46246	,036	,0553	2.7108
	3.00	,25806	,29169	,990	-.5794	1.0955
	5.00	-1,51971*	,44157	,009	-2.7875	-.2520
5.00	1.00	4,15278*	,56667	,000	2.5259	5.7797
	2.00	2,90278*	,56667	,000	1.2759	4.5297
	3.00	1,77778*	,43855	,001	,5187	3.0369
	4.00	1,51971*	,44157	,009	,2520	2.7875
*. The mean difference is significant at the 0.05 level.						

We note in Table 14 that the matrix of intergroup comparisons provides all types of comparisons, and the values of the differences of averages corresponding to each pair comparison have negative values (the group studying a smaller time interval versus the group that studies a larger time interval) and positive values (the group that studies a larger time interval versus the group that studies a smaller time interval). We observe the same values for the same pairs, but with changed sign depending on the meaning of the difference. In our analysis we will analyze only statistically significant positive differences, denoted by asterix (*).

We have seven such comparisons, for which we will calculate the value of the coefficient t according to the formula below, on the basis of which we will calculate the magnitude of the effect r, for each significant comparison (the data is taken from Tables 13 and 14, and the value from the denominator in the formula for calculating r is identical for all pairs).

For 3-1 pair (1 hour – 1.50 hours versus 0-30 minutes) we have:

$$t_G = \frac{MD}{SE} = \frac{2{,}37}{0{,}45} = 5{,}26$$

$$r = \sqrt{\frac{t^2}{F(df_1) + df_2}}$$

$$r = \frac{7{,}41}{\sqrt{15{,}73 \cdot 4 + 84}} = \frac{7{,}41}{12{,}12} = 0{,}43$$

Similarly we proceed for all pairs, and the results are listed in Table 15, ranked in descending order of the value of r.

Table 15. Value of t and effect size for pair comparisons

Curr. No.	The pair	MD	SE	T	P	R	Effect size
1.	5: over two hours 1: 0-30 minutes	4,15278*	,56667	7.33	,000	0.60	strong
2.	4: 1.50-2 hours 1: 0-30 minutes	2,63306*	,46246	5.69	,000	0.46	medium
3.	3: hour – 1.50 hours 1: 0-30 minutes	2,37500*	,45958	5.26	,000	0.43	medium
4.	5: over two hours 2: 30 minutes – 1 hour	2,90278*	,56667	5.12	,000	0.42	medium
5.	5: over two hours 3: hour – 1.50 hours	1,77778*	,43855	4.05	,001	0.33	medium
6.	5: over two hours 4: 1.50-2 hours	1,51971*	,44157	3.44	,009	0.28	weak
7.	4: 1.50-2 hours 2: 30 minutes – 1 hour	1,38306*	,46246	2.99	,036	0.24	weak

Students who study for more than an hour have significantly better results than those who study for less than this time interval. For pairs where we have statistically significant differences, the value of r decreases from r = 0.60 (strong effect) corresponding to pair 5-1, to r = 0.24 (weak effect) corresponding to pair 4-2. For four of the six pair groups the effect of r is medium, ranging from 0.33 to 0.46.

School results in mathematics and the anticipated time of study, if mathematics were not an exam discipline

The high weight that the math grade has in the average of the National Assessment exam in Romania determines an additional pressure on the students and, implicitly, a greater number of hours dedicated to the study of this discipline, especially in the last year of the secondary school. In fact, there is a statistically significant difference between the time allocated to the study of mathematics by the students of the eighth grade, compared to the students of the seventh grade. The Mann-Whitney U test for independent samples also demonstrated the fact observed by us and anticipated that the transition of students to a higher level class, namely from seventh to eighth grade, leads to an increase in the number of hours of study in mathematics. The research data reflect statistically significant differences, U = 532, z = -3,852, p = 0,000, r = 0,40, which shows a medium effect of the influence of the students' grade on the time devoted to study. Mean ranks are in favor of eighth graders MRVIII = 56.36, compared to MRVII = 36.14 in seventh graders.

For this reason, we also analyzed the existence of a statistically significant difference between the time devoted to the study in the current conditions and the time that would be devoted if this did not happen. A statistically significant difference would mean, from our point of view, that most students do not learn mathematics out of passion, for pleasure, but in order to have good exam results.

The data were analyzed by means of the Wilcoxon test to compare two pair-variables, the time devoted to the study of mathematics (timpstd), respectively the anticipated study time, if mathematics were not an exam discipline (timpst2), according to the data in Tables 16 and 17.

Table 16. Ranks

		N	Mean Rank	Sum of Ranks
Timpst2-Timpstd	Negative Ranks	58a	32.38	1878.00
	Positive Ranks	6b	33.67	202.00
	Ties	25c		
	Total	89		
a. Timpst2 < Timpstd				
b. Timpst2 > Timpstd				
c. Timpst2 = Timpstd				

Table 17. Test Statisticsa

	Timpst2-Timpstd
Z	-5,887b
Asymp. Sig. (2-tailed)	,000
a. Wilcoxon Signed Ranks Test	
b. Based on positive ranks.	

$$r = \sqrt{\frac{z^2}{n}} = 0{,}62$$

According to the data in Table 16, negative ranks predominate (58 cases in which the rank of the variable anticipated time is less than the dedicated time), followed by a number of 25 cases of equality (28.08% of students), respectively a number of 6 students who consider that they would be more motivated to devote more time to the study of mathematics if this were not an exam discipline. From Table 17, we note that z = -5.887, p = 0.000, which shows significant statistical differences between the two variables. Following the analysis of the values for the Sum of Ranks, we note that the meaning of the difference is in favor of the negative ranks, corresponding to the pairs of students who specified a shorter study interval if mathematics were not an exam subject, than those who specified the time interval they allocate now. The magnitude of the effect r = 0.62 shows a strong effect of the absence of the discipline of mathematics as an exam discipline in terms of the time allotted for the study of this discipline.

A last analysis was dedicated to highlighting a statistically significant relationship between the students' anticipated time to study mathematics and the students' average, through the method of ANOVA One-Way variance analysis. Unlike the current situation, no student specified an interval of more than two hours of study, so we have only four groups, corresponding

to the first four time intervals. These groups comply with the condition of homogeneity of variances (Levene test F(3, 85)

= 1.254, p = 0.295, p > 0.05), necessary to apply the ANOVA method (Tables 18, 19, 20).

Table 18. Descriptives

Average in mathematics								
	N	Mean	Std. Deviation	Std. Error	95% confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1.00	11	6.7273	1.67874	,50616	5.5995	7.8551	5.00	10.00
2.00	32	7.6875	1.20315	,21269	7.2537	8.1213	5.00	10.00
3.00	37	8.3243	1.51023	,24828	7.8208	8.8279	5.00	10.00
4.00	9	8.8889	1.26930	,42310	7.9132	9.8646	6.00	10.00
Total	89	7.9551	1.50688	,15973	7.6376	8.2725	5.00	10.00

Table 19. Test of Homogeneity of Variances

Average in mathematics			
Levene Statistics	df1	df2	Sig.
1.254	3	85	,295

Table 20. ANOVA

Average in mathematics					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31.766	3	10.589	5.356	,002
Within Groups	168.054	85	1.977		
Total	199.820	88			

The data from Table 20 lead to the conclusion that there are significant differences regarding the average obtained by students in mathematics and the anticipated time of study of this subject, if it were not an exam test: the omnibus test F and the significance threshold from the main ANOVA Table have the value F (3, 85) = 5.356, p = 0.02 (p < 0.05). In addition, we note in Table 18 Descriptive that the lowest mean (M = 6,72) was calculated for students who consider that they would devote the least time to study (0 – 0.5 hours), and the highest mean (M = 8,88) for those who anticipate that they would learn between 1.5 – 2 hours daily.

Through a post hoc Hochberg GT2 test we will find out between which of the groups of students there are significant differences (see Table 21).

Table 21. Multiple Comparisons

Dependent Variable: Average in mathematics Hochberg						
(I) Timpst2	(J) Timpst2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.96023	,49145	,279	-2.2826	,3621
	3.00	-1,59705*	,48288	,008	-2.8963	-.2978
	4.00	-2,16162*	,63199	,006	-3.8621	-.4611
2.00	1.00	,96023	,49145	,279	-.3621	2.2826
	3.00	-.63682	,33944	,323	-1.5502	,2765
	4.00	-1.20139	,53053	,145	-2.6289	,2261
3.00	1.00	1,59705*	,48288	,008	,2978	2.8963
	2.00	,63682	,33944	,323	-.2765	1.5502
	4.00	-.56456	,52260	,859	-1.9707	,8416
4.00	1.00	2,16162*	,63199	,006	,4611	3.8621
	2.00	1.20139	,53053	,145	-.2261	2.6289
	3.00	,56456	,52260	,859	-.8416	1.9707
*. The mean difference is significant at the 0.05 level.						

From the analysis of Table 21 we note that we have only two statistically significant comparisons, for which we will calculate the value of the coefficient t according to the formula below, based on which we will calculate the magnitude of the effect r, for each significant comparison (the data are taken from Tables 20 and 21, and the value from the denominator in calculating r is identical for all pairs).

For the pair: 3-1 (1 hour – 1.50 hours versus 0-30 minutes)

$$t_G = \frac{MD}{SE} = \frac{1{,}59}{0{,}48} = 3{,}31$$

$$r = \sqrt{\frac{t^2}{F(df_1) + df_2}}$$

$$r = \frac{3{,}31}{\sqrt{5{,}35 \cdot 3 + 85}} = \frac{3{,}31}{10{,}05} = 0{,}33$$

For 4-1 pair (1.5 hours – 2.00 hours versus 0-30 minutes), t = 3.42, and r = 0.34.

We note that students who would devote more than one hour a week to mathematics have better results than those who think they would devote between 0-30 minutes. For pairs where we have statistically significant differences, the values of r are very close, but the effect is medium.

Discussion and conclusions

The study aimed to provide new research data regarding the impact of attitudes, motivations and learning time on school results in mathematics, considered by recent research in the educational field among the key elements of the student's educational success. The research also aimed to verify for the context of secondary education in Romania the conclusions of recent researches that have taken into account learning in mathematics. Our investigative approach is further justified by research data that shows that there is a declining interest of students in learning mathematics internationally, although efforts are being made for the teaching of notions to include their applicative dimension and to use interactive didactic strategies, including by integrating new technologies into lessons. Research confirms the need for additional investigations to contribute to a better understanding of the stages and mechanisms that support learning in mathematics and achieving good results in final assessments by students in the last two classes of secondary education (13-15 years) (Aguilar, 2021; De la Peña et al., 2021).

A novelty aspect of the research is the investigation of the ratio of students' interest in learning in different subjects, relative to learning and results obtained in mathematics. In the context in which international research shows that one of the factors of failure in learning mathematics is the anxiety manifested in relation to studying in this discipline (Ardura et al., 2023), respondents were invited to mention their favorite educational discipline. We analyzed in the research whether the anxiety manifested in relation to learning in mathematics is due to the affinities that students have towards other educational subjects, epistemologically distant from mathematics. Research data show that there are no statistically significant differences in the choice of other subjects (epistemologically close or epistemologically distant) and the average obtained in mathematics. However, students with a negative attitude towards mathematics tend to show little interest in other subjects as well, suggesting a general attitude of rejection of school learning. Regarding the good results in mathematics of students who have personal affinities for other educational subjects, epistemologically distant from mathematics, the data confirm that in these cases

the good results depend largely on the general interest in their own training and on the individual sustained study (Damrongpanit, 2019; Opris & Opris, 2024).

The study aimed to verify and customize the data of international research that indicated the motivations that secondary school students have among the determinants for learning mathematics. Respondents who chose as motivation for learning mathematics the essential role that this discipline has in organizing logical thinking are found in different percentages on all six values of averages, but the majority (77.4%) have averages above eight. Also, respondents who are motivated by the fact that they have results in mathematics, even if for this they have to allocate a much larger time interval, record averages in the range of 7-10. For those who learn for pleasure, the highest averages are recorded, more than half of the students who made this choice (54.6%) have averages of 9 and 10. We believe that the data confirm that positive internal motivation is the one that supports learning in mathematics and achieving performance, which requires reconsideration of some pedagogical approaches (Jahanifar, 2022; Robas et al., 2020).

Another important novelty aspect of the research was the investigation of the possible role of parents in learning mathematics, in the context in which this role is most often perceived by students as a negative extrinsic motivation. We were interested to find out if for all students the attitude of parents to their results in mathematics is perceived as a form of emotional pressure. Also, data analyzes were carried out to highlight as a novelty factor which is the range of grades for which parental dissatisfaction is higher. Regarding the implications of parents' attitude in relation to the mathematics results of secondary school students, the results show that parents' dissatisfaction with poor results is found as motivation in students regardless of their average in mathematics, but over two thirds of those who chose this answer variant have averages between 5-7, the highest value (28.6%) being recorded in students with 7 as average in mathematics. It reconfirms the need for good emotional support of students, including reconsideration of some attitudes of parents, in the context in which internationally research shows that students show an increasingly low self-confidence, followed by passive behavioral attitudes in relation to learning mathematics (Galende et al., 2020; Li et al., 2021).

Previous research data present the role of motivation as a key factor in learning in mathematics and indicate this link as stable and little discussed at present (Suárez et al., 2019). In our research we considered it necessary to continue the investigations in order to highlight with statistically validated data the place of positive motivation in all the motivations of students in Romania, in order to obtain good results in mathematics (Ryan et al., 2022).

Thus, positive internal motivation was analyzed from the perspective of the importance it has in math learning in 13-15 years old students. In all three situations of paired comparisons in which there are statistically significant differences, negative external motivation has the lowest value of the mean rank. The best results are recorded in students who learn as a result of internal motivations. It confirms the major role of internal motivation, but also of positive education to support the school success of students (Chouinard & Roy, 2008; Ryan et al., 2022). Also, our sample confirms that the value-effort relationship attributed by students to learning in mathematics directly influences dedication and involvement in learning, which leads to a higher understanding of the usefulness of learning.

In our survey we wanted to check for the sample subjected to the research previous results that investigated the link between the time allocated to learning and the school results in mathematics (Kitsantas et al., 2011). The results of the research show that an increase in the average in mathematics is recorded with the increase in the number of hours daily study. Thus, the majority of students who learn little (87.5%) have poor results in mathematics (averages of 5 and 6) and the majority of those who devote more than two hours daily to learning mathematics (77.8%) have averages of 10. However, the data also show that there are respondents who, although allocating daily between 1.5 hours – 2 hours to the study of mathematics (33.3% and 25.8% respectively) have poor to medium grades. The results of the study confirm data from previous research that show the complex and nonlinear relationship between the number of study hours and the math results of middle school students (De la Peña et al., 2021; Kikas et al., 2022). The results are statistically significant in favor of the end-of-secondary school class, in which the increase in the number of hours devoted to mathematics is observed. At the same time, the research we carried out also suggests the existence of other factors, cognitive or socio-cultural, including implications of personal operating skills with knowledge from mathematics, the major role of individualistic structures of thought.

Recent meta-analyses have highlighted the generally internationally recognized need for further exploration of factors that moderate students' motivation for math learning (Li et al., 2021). Among the possible moderating factors of learning in mathematics, as an element of novelty, our study analyzes the prospect of admission of respondents to the desired high school, following a national assessment. Thus, at the item that asked the students' opinion about learning in mathematics in the situation that this discipline would not be among those in which they are evaluated for admission to high school, the data show a significant reduction in the time

allocated to study, regardless of motivation and grades in math. Thus, the lowest average (M = 6.72) was calculated for students who consider that they would devote the least time to study (0 – 0.5 hours), and the highest average (M = 8.88) for those who anticipate that they would learn between 1.5 – 2 hours daily. For pairs where we have statistically significant differences, the values calculated for r are very close, but the effect is medium. Low levels of performance in mathematics are associated, as in other research, with the status of the discipline within the national education system, with decreased confidence in mathematics or with the lack of active involvement in learning of 14-15 year olds (Li et al., 2021), but also with the lack of activizing didactic strategies able to compensate for these trends (Alvidrez et al., 2024; Poçan et al., 2023). We believe that the data indicate that at 13-15 years old secondary school students have not yet reached the understanding of the chances that learning mathematics offers for personal development and are limited mainly to immediate goals.

We believe that the study as a whole confirms research data showing the importance of attitude towards learning (Ker et al., 2023; Samuelsson, 2023) and the impact of learning in maths versus learning in other school subjects (Abín et al., 2020; Ardura et al., 2023). We also believe that the research data show that in Romania the school evaluation aims at medium to high level competences, but which are accessible for good results also to students who do not want to perform in mathematics, who have personal affinities towards other subjects, including those epistemologically distant.

Limitations

The methodological approach through the use of closed questions allowed the collection of valid data, all answers to items were included in statistical data analysis, which provided reliable results. The integration of the approach with mixed methods to complement the quantitative analyses presented in the study with qualitative perspectives could additionally help to identify relational and systemic factors that influence the analyzed results. The data provide important perspectives for learning mathematics in the last two grades of secondary education in Romania, from a school with good results in the national assessments at the end of the education cycle. The limited sample size indicates that the research focuses less on detailing the results from the perspective of sociological indicators. Expanding the research with respondents from different educational systems, with different perspectives on the role of learning for personal development and from different cultural landscapes can highlight additional practices and approaches and further support the generalization of our findings.

Directions of research development

The research results suggest possible directions for further investigation of aspects such as the implications of cognitive abilities and their connection with emotional and motivational abilities in learning mathematics (Abín et al., 2020; Ashcraft & Moore, 2009). Also, new investigations may bring further clarifications on the attitudes, motivation, opinion regarding the role of mathematics in personal training and differences in the attitude towards mathematics learning according to gender of secondary school students, starting from data indicating in boys a more favorable attitude towards mathematics. The research can be continued in order to investigate the impact on learning the type of knowledge required by school programs in mathematics, the role it has in learning the extent to which students consider trivial or on the contrary esoteric the notions they need to learn (Norton, 2016). We consider useful for education specialists investigations that highlight for different ages the ratio of results in mathematics and factors such as understanding of specific terms, the location of the school or the status of the school (Wakhata et al., 2022). Starting from the major implications for learning, we consider useful new research to detail aspects related to the efficient use of new didactic strategies in mathematics. Also, we consider that additional investigative steps are needed to identify the models for adopting schemes for allocating learning time to students, for different learning contexts, through which to support the achievement of good results in mathematics, in compliance with the ethics and deontology norms that they involve (Gjicali & Lipnevich, 2021).

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