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The relationship between mastery learning models and academic achievement in mathematics

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ABSTRACT

This study aims at highlighting the relationship between mastery learning models and academic performance in mathematics, moderated by the number of hours allotted to studying mathematics. There are 305 first to eighth-grade students who learn at *Nae A. Ghica Middle School* in Romania. Students in sixth, seventh, and eighth grades (n=101) were selected to participate in this research because they study both algebra and geometry. We have used purposive sampling to control certain variables, i.e., mastery learning strategies and academic performance. The data were analyzed in Jamovi (2022). The level of performance was measured according to the progress students made. Data analysis revealed that the moderation effect of the time each student allocated to studying mathematics individually is not statistically significant in the relationship between the mastery learning model and academic performance in mathematics. This study was conducted on a small number of students, so it is recommended to be expanded on a larger scale.

Keywords: efficient learning, mastery learning, progress

INTRODUCTION

The impact mathematics has on student formation is a topic that has aroused many controversies among teachers, students, and parents. What should a math teacher and his students do when it comes to learning mathematics effectively? The answer is a challenge for all of us especially since learning mathematics is influenced by many factors. Piaget (1966) stated that cognitive development depends on four main elements: the development of our nervous system and endocrine system, gaining experience during activities, social interactions, and the development of abstract thinking. This is the pattern to be followed when forming logical-mathematical skills. The part teachers play in creating and developing an efficient educational process is extremely important because they have the abilities and the knowledge to help children develop properly.

The mastery learning model developed by Bloom (1968) has been adapted and implemented in learning environments worldwide according to the characteristics of each domain, school subject, and group of students, and also according to the needs identified at a certain point in the teaching-learning process. Numerous studies (Doroudi, 2020; Hassan, 2022; Siddaiah-Subramanya et al., 2017; Toler, 2022) have proven the efficiency of this model and have contributed to being used by teachers and students all over the world.

The main stages of this model are analyzing and selecting essential content according to the school curriculum and to students' characteristics and needs, using it in short learning units, setting the objectives for each learning unit, using initial assessments to identify students' levels before the start of the instructional process, teaching new content while making use of interactive and motivating learning activities, applying formative assessments at the end of each learning unit, completing remedial and enrichment tasks, applying new formative assessments, and applying a summative assessment at the end of all learning units.

When selecting essential content, teachers must be aware of students' initial level of knowledge. The best way to identify their level is to apply an initial assessment to determine if students have the required knowledge, which will allow them to learn new content. If there are students who cannot reach the minimum performance level, teachers must adapt the mastery learning model and must explain some content, which may not be mentioned in the curriculum for that level but in that for a previous level. If previous content has not been properly understood and if it represents the base for new knowledge, it will be almost impossible for students to learn new content. Therefore, teachers must make sure that students have the required level of knowledge and that they have filled all information gaps before moving on to new learning elements. It is possible, especially when it comes to teaching mathematics, that students encounter difficulties because they have learning gaps. It is essential for teachers to check students' initial levels. If the outcomes are appropriate for students' level, proving that they have what it takes to move to a new learning unit, the teaching-learning process may begin.

Essential content must be taught in appropriate contexts to be easily and naturally assimilated. Understanding it is a decisive factor for later usage in real-life contexts. When implementing a mastery learning model, a deep understanding of concepts and information is valued as opposed to simply learning some things by heart.

Checking the proper understanding of new learning is done constantly through formative tests. The mastery learning model implies setting limits beyond students' current level to make them get out of their comfort zone and improve their learning performance. Understanding and learning new information and concepts must be encouraged in any type of learning. When teaching activities are connected to realities students are familiar with, they acquire learning content faster. Moreover, the connection between learning and real-life contexts leads to making analogies that help students acquire a deeper understanding of the subject.

According to the mastery learning model, formative tests represent the key element in monitoring students' progress and in identifying learning gaps and strengths. These tests can be adapted for online learning as well. They do not take long to complete and only check short learning sequences so students can pay proper attention when they are assessed. Studies conducted up to now (Gloria et al., 2018; Grothérus et al., 2019; McCallum & Milner, 2021) have shown the efficiency of formative tests in the teaching-learning process.

Besides their use as regular evaluation tools, formative tests determine students to get actively involved in the learning process and they also increase students' motivation. If students are successful in identifying their weaknesses and strengths, they will be motivated to overcome any obstacles and improve their learning. Completing remedial activities based on the identified learning needs leads to improving learning outcomes. On the other hand, if students succeed in obtaining the expected results, they will complete some enrichment activities that will help them broaden their horizons. The results of formative tests represent the feedback for a recently ended learning sequence.

Remedial and enrichment activities can be also completed online. Several apps can be used when creating such activities (GeoGebra, Kahoot, Quizizz, Wordwall, etc.). An advantage of online activities is the opportunity to complete them as many times as a student needs to learn new information properly. Another advantage is that these activities are interactive, and students' interests and motivation are aroused. Teachers can also use these apps in the classroom if they have the necessary digital tools and equipment.

An essential aspect when it comes to completing remedial activities is working in teams or pairs. Students can collaborate effectively and those who have obtained high results can explain the contents to those who have not succeeded in the first formative test. Students learn better from other students or when they are asked to explain some things to others. Collaborative learning can be a great benefit to all students.

The second formative test applied within the same learning sequence can be taken by all students or only by those students who did not reach the minimum performance level. If students who managed to reach the required level do not want to take the second test, they can be involved in enrichment activities. Formative assessments help students improve their results.

Feedback is another essential element in an efficient learning process. Both teachers and students can offer feedback. Teachers offer feedback when they check students' tests. The results can reveal students' strengths, weaknesses, and certain issues related to the teaching method. Teachers can identify which content has not been properly understood and they can change the way they teach and the instruments they use. Offering feedback is of great benefit to both students and teachers.

Summative assessment is important for monitoring students' progress in a complete and coherent learning sequence. Based on the comparison between initial results and final results, teachers can determine if the activities completed during classes, the formative tests, the feedback, and the remedial activities were appropriate for making the teaching-learning process more efficient.

The role allocated time has in the instructional process has been analyzed in many studies worldwide and the findings have shown that, in certain contexts, time allocated for learning is crucial for achieving performance. Moreover, researchers have emphasized the conditions required for this allocated time to be relevant in the teaching process (Andersen et al., 2016; Beattie et al., 2014; Guo et al., 2021; Ozyildirim, 2022; Valle et al., 2019; Wedel, 2021).

In the study, entitled *Increasing instruction time in school does increase learning*, Andersen et al. (2016) analyzed the relationship between the time allocated to the teaching-learning process and learning at school. The researchers collected data within a study conducted on a large scale. Even though it was thought that increasing school time would lead to students' exhaustion (Patall et al., 2010), the studies, which analyzed this particular aspect did not have conclusive data to prove this. Some other studies have shown that allocating more time for learning leads to improving performance (Jensen, 2013; Kikuchi, 2014; Parinduri, 2014). Moreover, when the time allocated to learning is related to some other variable, i.e., teachers' efficiency, "a teaching process based on data and facts, students' abilities or an improved pedagogy" (Andersen, 2016, p. 7481), it was shown that there are some positive effects of allocating more time to learning (Cortes & Goodman, 2014; Fryer, 2014). Participants in this study were 1931 students in fourth grade enrolled in 90 schools in Denmark. The time allocated for reading, writing, and literature was supplemented with three hours every week over 16 weeks. Students have been divided into two groups. For the first group teachers decided how to use the extra time according to students' needs and characteristics. For the second group teachers had to follow a detailed scheme of the activities. The results of this study showed that the level of learning increased for students in both groups. Nevertheless, the teaching-learning process that followed a strict scheme proved itself more efficient than the one, where the teacher could decide how to use the time (Andersen, 2016).

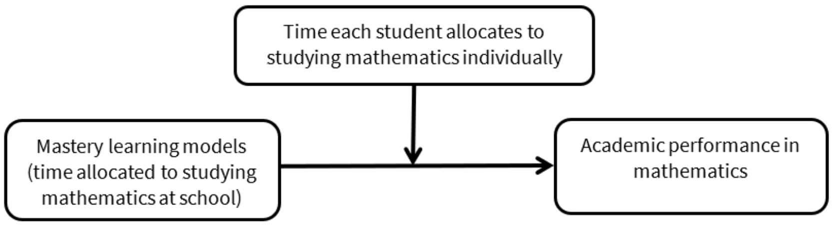

Figure 1. Moderation model (Source: Author's own elaboration)

Wedel (2021), in her article, *Instruction time and student achievement: The moderating role of teacher qualifications*, analyzed what the relationship between the time allocated to instruction and the quality of instruction is. Data collected from TIMMS (trends in international mathematics and science study) international assessments for fourth grade have been analyzed. Participants in this study were 115,071 students enrolled in 4,529 schools from 42 countries (Wedel, 2021). Students' results in mathematics and science, time allocated to studying these subjects at school, and teachers' formation (training courses, studies, and specializations) were some of the variables in this study. The researcher has shown that one extra hour allocated to learning each day has a positive effect on improving school results and these results are even better when qualified teachers do the teaching. The effect was smaller in developing countries because they allocate less time to the teaching-learning process than in developed countries. Nevertheless, results have improved in these countries as well because qualified teachers did the teaching (Wedel, 2021).

In *Time spent and time management in homework in elementary school students: A person-centered approach*, Valle (2019) analyzed four types of student profiles according to the time allocated to doing homework, time management, and the relationship between time allocated to individual study at home and academic performance. The study was conducted in 11 schools in Spain and the participants were 968 students (22.30% students in fourth grade, 41.70% students in fifth grade, and 36.00% students in sixth grade). Data regarding how much time students allocate to doing homework were collected through *encuesta sobre los deberes escolares* [*homework survey*] questionnaire. The questionnaire had the following structure: two items for monitoring time spent doing homework, two items for time management, and two items for the amount of homework students were able to do. Moreover, academic performance was determined through students' results in mathematics, sciences, English, and Spanish. Data analysis showed that students can be divided into four categories: 5.68% of them spend little time doing homework and fail to organize their time properly, 68.80% spend little time doing homework, but manage to organize their time efficiently, 16.80% manage their time properly and do the entire homework, and 8.68% spend a lot of time doing homework, but face difficulties in managing their time properly. In all cases, this study revealed that there is a relationship between time allocated to doing homework and academic performance. One essential role of this study was to emphasize the two time variables, i.e., the amount of time (number of hours) spent doing homework and the quality of time (the way this time is actually used).

The intensity of the relationship between the two variables (dependent variable and independent variable) is influenced by several moderators. Models regarding the moderation of the relationship between students' motivation and their need to compete (Bostan et al., 2021), between individualized teaching of mathematics and students' involvement in the learning process (Talbert et al., 2019), between students' initial academic achievement and their current performance (Biunno, 2019), and also between math performance and motivation (Baten et al., 2019) have been tested.

Each school subject has a significant role, but the fact that the national exam students sit in eighth grade in Romania is based on checking mathematics and Romanian language knowledge turned mathematics into an even bigger challenge for many students. According to the official reports of the Romanian Ministry of Education (www.edu.ro), the data related to students' academic achievement in mathematics in Romanian schools show that, between 2017 and 2022, less than 80.00% of eighth-grade students succeeded in obtaining scores above the minimum level of performance in the national exam (65.90% in 2017, 61.40% in 2018, 62.80% in 2019, 70.20% in 2020, 67.40% in 2021, and 77.50% in 2022).

This study was carried out to see if mastery learning strategies influence academic performance in mathematics for students in sixth, seventh, and eighth grades. Eighth-grade students who participated in this study sat the national exam in June 2022, and 89.00% of them managed to pass the exam, while only 76.00% of their peers managed to pass the same exam one year before this study was conducted.

Hypotheses

The analysis presented in this study highlights the relationship between mastery learning models and academic performance in mathematics, moderated by the number of hours allotted to studying mathematics. A model of moderation of the relationship between implementing mastery learning strategies during extra mathematics lessons in which students participate at school after the usual school schedule (independent variable) and academic performance (dependent variable) has been tested (**Figure 1**). The time each student allocates to studying mathematics at school without a teacher-student interaction acts as a moderator in this model.

Two hypotheses have been stated for this model.

H1. There is a relationship between the mastery learning model and academic performance in mathematics.

H2. The time allocated to studying mathematics individually at school acts as a moderator in the relationship between the mastery learning model and academic performance.

Table 1. Descriptive characteristics of study participants

	Initial assessment	Final assessment	Academic achievement	Mastery learning (number of hours)	Individual study (number of hours)
n	101	101	101	101	101
Mean	6.09	7.00	0.916	22.3	22.9
Median	5.70	6.80	0.750	24	24.0
Standard deviation	2.09	1.87	0.854	6.92	5.92
Minimum	2.65	3.80	-1.40	5	8
Maximum	10.0	10.0	2.85	30	30

Table 2. Descriptive characteristics of study participants by gender

	Gender	Initial assessment	Final assessment	Academic achievement	Mastery learning (number of hours)	Individual study (number of hours)
n	Male	49	49	49	49	49
	Female	52	52	52	52	52
Mean	Male	5.72	6.76	1.04	22.5	22.8
	Female	6.44	7.24	0.801	22.1	22.9
Median	Male	5.30	6.25	0.900	24	24
	Female	5.95	7.32	0.725	24.0	24.0
Standard deviation	Male	2.04	1.73	0.881	6.83	5.62
	Female	2.10	1.97	0.820	7.06	6.24
Minimum	Male	2.70	4.00	-0.300	7	8
	Female	2.65	3.80	-1.40	5	9
Maximum	Male	10.0	10.0	2.85	30	30
	Female	10.0	10.0	2.50	30	30

MATERIALS & METHODS

Participants

This study was conducted in a middle school in Romania, i.e., *Nae A. Ghica Middle School*. The participants in this study were 101 students (27 eighth-grade students, 45 seventh-grade students, and 29 sixth-grade students) (**Table 1** & **Table 2**).

Research Tools

The following research tools were used for collecting data. For eighth grade, the test created by the Romanian Ministry of Education for the simulation of the national exam (applied on 5th April 2022 in all Romanian schools), the test created by the Romanian Ministry of Education for the national exam students sit in eighth grade (applied on 16th June 2022 in all Romanian schools), the observation chart for each student to monitor their involvement in the mastery learning activities implemented at school, and an observation chart for the extra time they spent doing activities individually at school without the intervention of a teacher.

For seventh and sixth grades, students took an initial assessment in April 2022 and a final assessment in June 2022. These assessments were chosen according to the curriculum for each grade.

The tests used have the following structure: part 1–six objective items (multiple-choice items) in algebra, part 2–six objective items (multiple-choice items) in geometry, and part 3–six problems with complete solutions (three in algebra and three in geometry).

Procedure

A mastery learning model was implemented during mathematics lessons in a middle school in Romania, and observation charts were completed for each student to monitor the time spent in doing remedial and enrichment activities within the mastery learning strategy and the time spent doing activities individually at school under constant monitoring but without the teacher's intervention. Participants in this study were 101 students.

An initial assessment was applied to check students' achievement in mathematics. Following the analysis of the results, learning contents were chosen and the objectives for each unit were stated. Students completed tasks and at the end of each lesson they took a formative test in order to check their understanding of what had been taught. According to the results obtained in the formative tests, students received feedback and were involved in remedial and enrichment activities for one or two hours after the usual school schedule for two to three days a week (a total of 15 days in April and May), depending on students' needs. Some students needed more remedial activities while others only needed enrichment activities, which were optional. This teaching-learning process was repeated for each lesson. During the days when mastery learning strategies (remedial and enrichment activities) were not implemented students did activities individually at school under constant monitoring but without teacher's intervention (two to three days a week, a total of 15 days in April and May). These activities were not mandatory. During these activities, students did their homework or received extra worksheets. At the end of the learning sequence, students took a final assessment to check if they improved their academic performance. The observation charts for each student were filled in by the teacher at the end of each learning session.

Table 3. Initial & final assessments results–6th grade

Students	Initial assessment	Final assessment	Progress	Students	Initial assessment	Final assessment	Progress	Students	Initial assessment	Final assessment	Progress
E6A_1	3.20	5.60	2.40	E6A_11	4.50	4.20	-0.30	E6B_9	4.20	6.25	2.05
E6A_2	9.60	10.00	0.40	E6A_12	9.70	9.80	0.10	E6B_10	4.65	5.25	0.60
E6A_3	5.50	7.20	1.70	E6B_1	3.50	5.80	2.30	E6B_11	5.70	6.20	0.50
E6A_4	3.40	5.45	2.05	E6B_2	4.25	5.65	1.40	E6B_12	4.20	5.80	1.60
E6A_5	5.75	8.25	2.50	E6B_3	2.65	4.85	2.20	E6B_13	7.65	8.40	0.75
E6A_6	5.90	7.80	1.90	E6B_4	3.65	5.20	1.55	E6B_14	8.50	8.85	0.35
E6A_7	3.40	6.25	2.85	E6B_5	7.55	8.00	0.45	E6B_15	9.65	9.80	0.15
E6A_8	9.50	9.85	0.35	E6B_6	3.50	5.45	1.95	E6B_16	4.40	6.35	1.95
E6A_9	4.65	5.85	1.20	E6B_7	2.70	4.80	2.10	E6B_17	5.60	6.30	0.70
E6A_10	4.80	5.20	0.40	E6B_8	3.70	5.85	2.15				

For eighth-grade students, data were collected from the test created by the Romanian Ministry of Education for the simulation of the national exam (April 2022) and the test created by the Romanian Ministry of Education for the national exam (June 2022). Students' results in these tests were compared to see if mastery learning strategies influenced their academic performance in mathematics. For sixth and seventh grades, data were collected from the initial and final assessments, chosen according to the curriculum for each grade. Another comparison was made between the results obtained by seventh-grade students and sixth-grade students in these two assessments. For monitoring students' involvement in mastery learning activities and in activities completed individually at school (i.e., individual study), data were collected from observation charts filled out by the teacher with information about the amount of time spent completing these two types of activities.

Quantitative data analysis methods were used due to the fact that test results were compared to see if the implemented mastery learning strategies influenced students' academic performance in mathematics. First, descriptive analysis was used in this study to present the characteristics of study participants, i.e., the number of participants, their gender, the mean, and the lowest and highest scores obtained in the initial and final assessments, the amount of time spent doing mastery learning activities and the amount of time spent completing activities individually. Second, exploratory analysis was used to highlight the relationship between mastery learning strategies (independent variable) and academic performance in mathematics (dependent variable) in which the time allocated to studying mathematics individually functioned as a moderator.

Considering three time variables implied by the original mastery learning model, i.e., "*aptitude* (the time a student needs to learn everything he is supposed to), *opportunity to learn* (the time allocated to learning), and *perseverance* (the time a student is willing to spend learning)" (Carroll, 1989), following variables were taken into account in this study: mastery learning model represented by number of hours allocated to studying mathematics at school based on a teacher-student interaction along with the completion of remedial and enrichment activities (independent variable) and academic performance (dependent variable).

The purpose of this study was to analyze the relationship between the time allocated to learning mathematics and mastery learning models, not during normal school lessons but during extra lessons students took part in at school after the usual school schedule (one or two extra hours in which they completed remedial and enrichment activities) and during activities they completed by themselves at school (one or two hours per day). The time for the four lessons students usually had in mathematics at school was not included in the analysis. The mastery learning model was implemented over two months (April, May), during the days when students also had math lessons in their school schedule, i.e., 15 days. An initial assessment was applied, new content was taught in the selected learning units with the purpose of achieving specific learning goals, formative assessments were applied at the end of each math lesson, students were actively involved in remedial and enrichment activities, new formative tests were applied, and, at the end of all learning units, a summative test was taken by all students.

RESULTS

The data collected were analyzed in Jamovi (2022), a statistical software. According to general data protection regulation, students' names were encrypted, i.e., *S8_student number* (S–student, 8–eighth grade), *S7A_student number* (S–student, 7A–seventh grade A), *S7B_student number* (S–student, 7B–seventh grade B), *S6A_student number* (S–student, 6A–sixth grade A), *S6B_student number* (S–student, 6B–sixth grade B). The level of performance was measured according to the progress students made, i.e., the difference between simulation test results and national exam results or between the initial assessment and the final assessment. The number of hours students spent on doing activities related to the mastery learning model and the number of hours students spent on doing individual activities without the help of a teacher were noted in the observation charts. The first were the independent variable and the second were the moderator of this model.

A comparison was made between the results obtained by sixth-grade students in the initial and final assessments (**Table 3**). Most students, i.e., 28, succeeded in improving their academic performance in mathematics as a result of the implementation of mastery learning strategies. Their scores increased by 0.10 to 2.85 points. Only one student did not succeed and obtained a lower score in the final assessment.

Another comparison was made between the results obtained by seventh-grade students in the initial and final assessments. Most students, i.e., 36, succeeded in improving their academic performance in mathematics as a result of the implementation of mastery learning strategies. Their scores increased by 0.05 to 2.55 points. Three students had the same results in both assessments and six students did not succeed and obtained a lower score in the final assessment (**Table 4**).

Table 4. Initial & final assessments results–7th grade

Students	Initial assessment	Final assessment	Progress	Students	Initial assessment	Final assessment	Progress	Students	Initial assessment	Final assessment	Progress
E7A_1	10.00	10.00	0.00	E7A_16	4.25	5.65	1.40	E7B_5	9.65	9.70	0.05
E7A_2	3.40	4.80	1.40	E7A_17	4.15	5.20	1.05	E7B_6	4.20	4.00	-0.20
E7A_3	8.70	9.00	0.30	E7A_18	9.30	9.85	0.55	E7B_7	5.35	7.10	1.75
E7A_4	6.50	6.40	-0.10	E7A_19	5.30	5.80	0.50	E7B_8	7.20	8.35	1.15
E7A_5	9.25	10.00	0.75	E7A_20	4.60	5.35	0.75	E7B_9	5.40	5.20	-0.20
E7A_6	6.60	6.40	-0.20	E7A_21	8.65	9.00	0.35	E7B_10	4.30	5.75	1.45
E7A_7	8.20	9.35	1.15	E7A_22	5.70	7.35	1.65	E7B_11	4.10	5.00	0.90
E7A_8	7.60	8.30	0.70	E7A_23	3.40	4.80	1.40	E7B_12	5.20	4.85	-0.35
E7A_9	6.55	7.30	0.75	E7A_24	4.00	3.80	-0.20	E7B_13	4.70	4.85	0.15
E7A_10	8.70	9.60	0.90	E7A_25	4.50	5.00	0.50	E7B_14	4.50	5.25	0.75
E7A_11	9.60	9.85	0.25	E7A_26	5.20	5.60	0.40	E7B_15	8.65	9.45	0.80
E7A_12	10.00	10.00	0.00	E7B_1	4.80	7.35	2.55	E7B_16	7.60	8.35	0.75
E7A_13	9.50	9.80	0.30	E7B_2	5.30	6.80	1.50	E7B_17	10.00	10.00	0.00
E7A_14	7.20	9.25	2.05	E7B_3	4.80	6.25	1.45	E7B_18	3.40	4.50	1.10
E7A_15	3.60	4.30	0.70	E7B_4	6.25	8.10	1.85	E7B_19	3.20	5.35	2.15

Table 5. Simulation & national exam (NE) results–8th grade

Students	Simulation of NE	NE	Progress	Students	Simulation of NE	NE	Progress	Students	Simulation of NE	NE	Progress
E8_1	8.65	9.60	0.95	E8_10	3.50	6.00	2.50	E8_19	5.70	7.20	1.50
E8_2	6.75	7.40	0.65	E8_11	5.00	5.55	0.55	E8_20	6.85	7.90	1.05
E8_3	9.15	9.15	0.00	E8_12	5.00	7.00	2.00	E8_21	6.85	6.90	0.05
E8_4	8.25	10.00	1.75	E8_13	6.00	6.50	0.50	E8_22	6.65	7.60	0.95
E8_5	8.50	8.75	0.25	E8_14	4.00	3.80	-0.20	E8_23	5.45	5.15	-0.30
E8_6	5.60	6.40	0.80	E8_15	6.75	7.15	0.40	E8_23	5.40	7.75	2.35
E8_7	5.90	8.10	2.20	E8_16	7.80	7.95	0.15	E8_25	4.60	4.20	-0.40
E8_8	6.05	6.05	0.00	E8_17	8.10	9.20	1.10	E8_26	8.75	9.25	0.50
E8_9	6.00	4.60	-1.40	E8_18	8.80	9.30	0.50	E8_27	5.90	6.85	0.95

Table 6. Correlation matrix

		Academic achievement	Individual study (number of hours)	Mastery learning (number of hours)
Academic achievement	Pearson's r	-		
	p-value	-		
Individual study (number of hours)	Pearson's r	0.231*	-	
	p-value	0.020	-	
Mastery learning (number of hours)	Pearson's r	0.359***	0.618***	-
	p-value	<.001	<.001	-

Note. *p<.050; **p<.010; & ***p<.001

Another comparison was made between the results obtained by eighth-grade students in the simulation of the national exam and the national exam. Most students, i.e., 21, succeeded in improving their academic performance in mathematics as a result of the implementation of mastery learning strategies. Their scores increased by 0.05 to 2.50 points. Two students had the same results in both exams and four students did not succeed and obtained a lower score in the national exam (**Table 5**).

Correlation coefficients were calculated in Jamovi (2022) to answer the following questions (**Table 6**).

1. What is the relationship between the mastery learning model and academic performance?
2. What is the relationship between the mastery learning model and the time allocated to studying mathematics individually?
3. What is the relationship between the time allocated to studying mathematics individually and academic performance?

It can be noticed that the relationship between the mastery learning model and academic performance is statistically significant with a $p<0.001$ value and a correlation of 0.359. The relationship between the mastery learning model and the time each student allocated to studying mathematics individually is statistically significant, with a $p<0.001$ value and a correlation of 0.618. The relationship between academic performance and the time each student allocated to studying mathematics individually is statistically significant, with a $p<0.500$ value and a correlation of 0.231. Due to the fact that all correlations are positive, we could state that students make more progress both when a mastery learning model is implemented and when they study more individually. Next, a model of moderation of the relationship between the mastery learning model and academic performance in which the time allocated to studying mathematics individually acts as a moderator was tested (**Table 7**, **Table 8**, & **Figure 2**).

Data analysis revealed that the moderation effect of the time each student allocated to studying mathematics individually is not statistically significant in the relationship between the mastery learning model and academic performance in mathematics having a value of $p=0.564$ ($p>0.050$). Therefore, the effect of the mastery learning model was statistically significant ($p<0.001$), but the time each student allocated to studying mathematics individually was not statistically significant ($p=0.936$).

Table 7. Moderation model (estimates)

	Estimate	Standard error	Z	p-value
Mastery learning (number of hours)	0.04339	0.01174	3.6973	<.001
Individual study (number of hours)	-0.00108	0.01338	-0.0808	0.936
Mastery learning (number of hours)×individual study (number of hours)	-0.00108	0.00186	-0.5775	0.564

Table 8. Simple slope analysis (estimates)

	Estimate	Standard error	Z	p-value
Average	0.0434	0.0118	3.69	<.001
Low (-1SD)	0.0497	0.0142	3.50	<.001
High (+1SD)	0.0371	0.0178	2.09	0.037

Note. It shows effect of predictor (mastery learning) on dependent variable (academic achievement) at different levels of moderator (individual study)

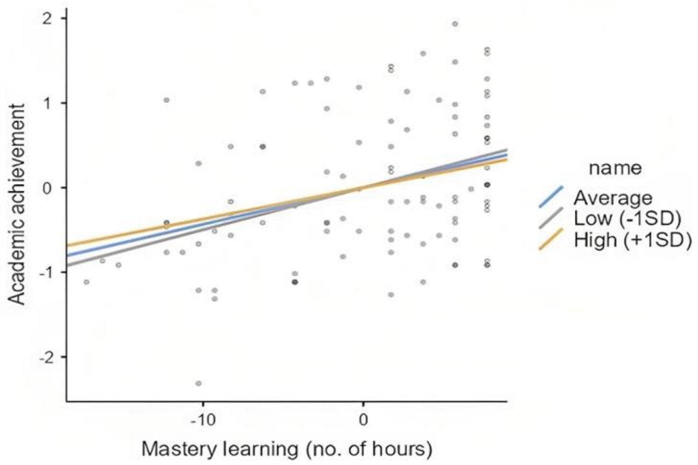

Figure 2. Moderation model diagram: Simple slope plot (Source: Author's own elaboration, using Jamovi software version 2.3)

This moderation model proved the efficiency of the mastery learning strategy in improving academic performance. The lack of interaction between the teacher and the students, the impossibility of constantly monitoring students' activities, and the lack of guided instruction determine the relationship between the time allocated to individual study and academic performance. This moderation model showed that this time does not affect the essential role of the remedial and enrichment activities based on the mastery learning model used at school.

DISCUSSION

The study aimed at analyzing the relationship between implementing mastery learning strategies (independent variable) and academic performance (dependent variable) in which the time allocated to studying mathematics individually functioned as a moderator. The current study has revealed the fact that there is a relationship between mastery learning models and academic performance in mathematics. The implemented mastery learning models consisted of teacher's instruction, interaction between the teacher and the students, monitoring students and engaging them in supplementary remedial and enrichment activities done at school but outside mandatory school classes. This study presents findings, which describe how time spent on doing activities in a teacher-monitored environment leads to improving academic results. Andersen et al. (2016), Valle et al. (2019), and Wedel (2021) highlight the importance of time spent on doing supplementary activities and also of the quality of instruction, both related to mastery learning models.

The mastery learning model implemented within this study highlights the effectiveness of time spent on remedial and enrichment activities under the constant and close monitoring of a teacher. Extra time allocated to learning has a positive effect on improving school results especially when well-trained teachers are involved in the teaching-learning process (Wedel, 2021).

The findings of this study reveal that extra time spent on remedial and enrichment activities in a teacher-monitored process leads to improving academic achievement, whereas the time spent on doing activities individually without the help of a teacher does not contribute to obtaining better results in mathematics.

Limits & Recommendations

Firstly, this study was conducted on a small number of students, so it is recommended to be expanded on a larger scale. Secondly, the learning content was selected from the curriculum for fifth grade to eighth grade. The concepts were divided into two categories, i.e., previous knowledge and content that was taught during each particular grade. Thirdly, the relationship between the selected teaching method and academic performance in mathematics is influenced by multiple factors, which should be analyzed, i.e., students' cognitive level, their aptitude for learning mathematics, and their motivation.

CONCLUSIONS

Education systems worldwide have been subject to numerous reforms meant to adapt teaching-learning processes to social, cultural, and economic changes and also to the needs and characteristics of new generations of students. Making this process more efficient is only possible through the continuous efforts of teachers, students, parents, and communities.

This study has shown that the mastery learning model can be adapted to the learning conditions in Romanian schools, being successful, making the teaching-learning process more efficient, and helping students improve their results.

There is a relationship between the time each student allocates to studying individually and academic performance in mathematics, which has a positive effect on students' progress, but this time cannot replace the teaching method and does not influence its effect on students' learning.

The mastery learning model has a positive effect on academic performance. The relationship and interaction between teachers and students are also of significant importance. They improve the quality of the teaching-learning process. Moreover, the feedback teachers give to students and the guided instruction are other essential factors that contribute to forming mathematical competencies, leading to improving academic performance.

Remedial and enrichment activities helped students improve their results. It is important to make sure that all students benefit from extra activities. The mastery learning model supports learning at school, an aspect that was emphasized in this study. It represents an efficient strategy for the teaching-learning process even though the average of hours allocated to learning mathematics at school while using a mastery learning model (22.3 hours) is lower than the average of hours each student allocated to studying mathematics individually (22.9 hours).

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Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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