Article

Metacognitive Strategies Related with Logical–Mathematical Thinking for Adolescents with ADHD

Georgios Tsampouris * and Begoña Esther Sampedro Requena (ID)

Department of Education, University of Córdoba, 14004 Cordoba, Spain; bsampedro@uco.es
* Correspondence: geotsa7@gmail.com or z62tstsg@uco.es; Tel.: +30-69-7602-4062

Abstract: This article focuses on the contributions of the still-scarce corroborations available on the social nature of the metacognitive regulation of joint attempts in order to offer systematic means to operationalize and analyze shared regulation. The mathematical knowledge aims to achieve the metacognitive needs of students and, in particular, those with learning difficulties. The present research process aims to explain the relationship between the logical and mathematical thinking of students with ADHD in secondary education schools in Heraklion (Crete) and metacognitive awareness and academic motivation, including questions about pupils' logical–mathematical skills and logical decisions of life and problem solving. Appropriate psychometric tools are used to evaluate their performance as well as their short and medium-term and consequently their long-term goals. The results of the current study imply that, when students realize that teachers and their parents emphasize the essential process of learning, appropriate strategies can be shown to them to allow them to learn how to solve problems on their own. As a result, it is of great significance to point out the relationship between students' academic achievement and academic motivation.

Keywords: strategic planning; learning disorders; learning difficulties; ADHD; cognition; teaching and learning mathematics

MSC: 00A35; 97-00; 97B10; 97B50; 97C10; 97C20; 97C60; 97E50; 91E10; 97D70

1. Introduction

A chronic neurodevelopmental disorder that affects approximately 5% of school-aged children is attention-deficit/hyperactivity disorder (ADHD) [1], which is associated with clinically significant impairments in the family, peer and academic domains [2]. Academic difficulties associated with ADHD start early and often remain through middle and high school [3]. The extent of the subject above makes it necessary to study in-depth the perception that students have of the subject of mathematics in junior high schools in institutions of Greece on some psychological aspects, such as motivation towards homework, self-concept, self-esteem and peer relationships.

More specifically, the present study determines the connection between the academic performance of students of mathematics, especially the solving of mathematical problems, in the secondary stage (12–15 years old) in institutions in Greece and some aspects such as motivation, self-concept, self-esteem, relationships with peers, students' daily lives and all that the teaching society has.

1.1. Cognitive Process Factors of Incentives: Individual Goals to Be Achieved

One of the most common communications between teachers and students is undertaking the invitation of an attentive attitude [4], mainly in which performance is deficient, such as the issue of children with attention-deficit hyperactivity disorder (ADHD). Metacognition and performance create a relationship that can be ascribed to the fact that metacognition relates to students' ability to adjust knowledge and strategies and to regulate their own

learning as a result [5]. Furthermore, an individual's ability to use appropriate strategies and procedures also plays an important role in order to quickly and securely drive the organization and execution of the resolution plan. In recent years, studies of a child's ability to choose the right problem-solving strategy have essentially led to an indicator of whether the individual "knows how to learn", i.e., his metacognitive ability [6].

It is important to mention that the current relevance of investigating high-level strategies is related to performance goals which are positively associated with functional behaviors, such as high school performance. In other words, it seems that both learning objectives and performance goals are seen as incentives for approaching, as they are achieved by engaging students in academic activities. In general, the definition of metacognition is one's reflection on his/her way of thinking. Metacognition can be distinguished as thinking about the knowledge and skills that exist in the minds of individuals, who, in our study, are adolescents with ADHD [7].

Some instruments to measure metacognition in youth and adults are the Motivation and Learning Strategies Questionnaire and the Metacognitive Skills Inventory, known respectively as MSLQ and MAI. The MAI, which was used for this research, is an instrument that allows us to examine the metacognitive awareness of children, adolescents and adults, and it was created and validated by Schraw and Denninson (1994) [8]. Since then, this instrument has been widely used in different investigations, especially to demonstrate the relationship between metacognition and learning achievement [9,10].

1.2. Mathematics in Cognitive Processes in Students with ADHD

Mathematical competence, in line with recommendations of the European Parliament and the Council of the European Union, is defined as "the ability to develop and apply mathematical thinking in order to solve a range of problems in situations of everyday life" (2018, p. 9) [11]. The differences in the way children acquire mathematical abilities seem significant [12]. The cognitive explanations for these differences, as research has investigated, are both domain-general cognitive factors (i.e., factors related to learning various academic abilities) and domain-specific cognitive factors (i.e., factors specifically related to mathematics learning) as well [13,14]. The relationship between metacognition and general academic performance has been largely considered. Vo et al. (2014) [15] noticed that children's metacognitive skills in the numerical domain predict their general school-based mathematics awareness and suggested that children's metacognition is a domain-dependent cognitive skill in adolescents.

Cooperation in metacognitive learning seems meaningful for students when considering new concepts and developing mathematical causality [16]. On the other hand, academic underachievement is apparent in those with ADHD, with approximately 33–63% of children with ADHD displaying difficulties in many school subjects, such as math [17]. ADHD academic difficulties usually appear early and are often persevered through middle and high school [3]. Furthermore, ADHD-related academic difficulties are correlated with countless negative results, including increased repercussions of failing grades, lower grade point averages and standardized test scores, higher rates of high school dropout and lower college presence, especially when they are compared to typically developing children of the same age [18].

Summarizing the above, the cognitive process factors of incentives are achieved by engaging students in academic activities. Particularly referring to mathematical competence, differences in the ways that children acquire mathematical abilities appear significant, especially when taking into consideration adolescents with ADHD, whose academic underachievement is apparent.

The general objective pursued in this research was to know the perception, namely the way of thinking, that students have of the subject of mathematics in junior high schools in Greece on specific psychological aspects, such as motivation towards homework, self-concept, self-esteem and peer relationships. The novelty of the present study lies in the fact

that metacognitive factors in relation to mathematical competence were studied exclusively in students with ADHD.

Therefore, numerous questions can be brought up, which simultaneously have teaching, academic, psychometrical and daily value. Therefore, a research question that arose was related with the significant difference between the learning design of children with ADHD and their metacognitive skills, which are indirectly related with their life decision plans. In addition, another question was whether there is a significant difference between the learning management of children between the age of 12 to 15 years old with ADHD and their socio-demographic characteristics or their last-year performances in mathematics.

The following research questions were created to attain the aim comprehensively:

1. Is there any significant difference between students' academic achievement, metacognitive awareness and academic motivation, and their socio-demographic characteristics or their last-year performances in mathematics?
2. Are there significant differences between the performances of students (girls and boys) from 12 to 15 years old and task motivation?
3. Are there significant differences between student performances in mathematics and their school area?
4. Are there significant differences between student performances in mathematics and their last-year performances in mathematics?

2. Materials and Methods

2.1. Research Setting and Participants

The research sample consists of 12–15 year old students with ADHD (attention-deficit hyperactivity disorder) attending secondary school units (17 schools in total in both urban and non-urban area) in Heraklion, Crete, both in integration and in the general classroom. The sample selection criterion was carried out in an appropriate manner, as indicted by the knowledge of the Educational and Counseling Support Centers, which, in conjunction with the Public Pediatric Medical Centers, are ultimately responsible for the diagnosis, differentiation and development of appropriate interventions and support programs in accordance with legislation [19,20].

In a non-probability sample, such as in the present study, there is no way to calculate the probability that each individual has to be included in the sample. Thus, the selection of the sample was made randomly through the common characteristic of students with ADHD. After dividing the sample into groups, between the schools in urban and non-urban areas, the selection of members was made only on the basis of convenience (simple random sampling), in which the research was held for the most easily accessible people to participate in the research.

The sampling method used is feasibility sampling [21], as it refers to the selection of certain population groups that satisfy specific assumptions, which, for the needs of our research, include students with ADHD.

Below, descriptions of each variable, used separately, are presented.

In Table 1, it can be seen that the sample of 110 students participating in this study shows that almost 30% of them are female, and more than 70% are male. In this sample, 36.4% studied in the 1st class of junior high school, and 31.8% were in the 2nd and 3rd class. About 60% of the children participating in this investigation were living in an urban area (city of Heraklion), and the rest of them were living in a non-urban area (40.9%). The table below illustrates the percentages of the last-year performances in mathematics as well. Most of the children (30%) had a performance of 13–14, whereas close to 20% were children with a last-year performance of 11–12 and 15–16. A few low percentages show performances that are lower than 10 (9.1%) and more than 17 (7.3–8.2%).

Table 1. Socio-demographic variables.

	Percentage	Frequency
1. Gender		
Male	72.7%	80
Female	27.3%	30
2. Class [1]		
1st class	36.4%	40
2nd class	31.8%	35
3rd class	31.8%	35
3. School Area		
In the city of Heraklion	59.1%	65
Out of the city of Heraklion	40.9%	45
4. Last-year Degree in Mathematics [2]		
Lower than 10	9.1%	10
11–12	21.8%	24
13–14	30.0%	33
15–16	23.6%	26
17–18	7.3%	8
19–20	8.2%	9

[1] The classification of classes into 3 levels, meaning the 3 classes of junior high school [2] The calibration of the performances in mathematics (also in all lessons) is from 0 to 20 (with 10 as the basis).

Table 2 shows that almost half of those who were surveyed have attention-deficit (43.6%), and only 11.8% were diagnosed with attention-deficit, hyperactivity and impulsivity. Moreover, 29.1% of the students showed attention deficit and impulsivity, and 15.5% showed attention deficit and hyperactivity.

Table 2. Descriptions of the sample in relation to ADHD.

	Frequency	Percentage
Attention-Deficit	48	43.6%
Attention-Deficit and Hyperactivity	17	15.5%
Attention-Deficit and Impulsivity	32	29.1%
Attention-Deficit and Hyperactivity and Impulsivity	13	11.8%
Total	110	100.0%

Note: Source: own elaboration.

2.2. Implementation of the Instrument

Concerning the data availability statement, the researchers ensured the consent of the parents and guardians of the pupils; the anonymity of the research participants and their protection, in accordance with the existing legislation of their sensitive personal data [22]; the provision of the possibility for research participants to terminate their participation; as well as the process of collecting research data being compatible with international treaties and conventions related to human rights in education [23]. Thus, all participants were fully informed that their anonymity was assured, why the research was being conducted, how their data were to be used and if there were any risks associated. As with all research involving humans, ethical approval from the Institute of Educational Policy from the ethics committee of the Ministry of Education of Greece was obtained prior to conducting the study, with assignment decision number 73541/D2/13-05-2019.

The scale measuring cognitive process questions, such as depth strategies, metacognitive strategies, surface strategies and self-regulation strategies, consists of 18 questions and is separated into 5 sub-categories.

This scale is part of the MAI validated instrument [24], which makes it possible to identify the metacognitive abilities of subjects through specific specialized questions divided into two categories: knowledge of cognition and regulation of cognition, which, in turn, are divided into other more specific categories:

- Planning: Developing a solution method, describing solution plans or selecting solution plans for a given problem.
- Organization: Determining how elements fit within a structure.
- Monitoring: Determining whether a process or product has internal consistency, detecting the effectiveness of a procedure as it is being implemented.
- Depuration: Eliminating all observations with missing data in any of the selected variables.
- Evaluation: Judging the values of ideas, materials and methods by developing and applying standards and criteria.

This questionnaire guarantees its validity and reliability, since the reliability value for academic achievement tests should be 0.65 and higher [25]. With respect to the research's internal consistency and reliability, the Cronbach's alpha is 0.87 for the cognitive process questions strategies.

2.3. Analysis Strategies

The data obtained are of a quantitive nature and were analyzed with a statistical program, specifically, the SPSS v18, performing descriptive and inferential tests. In this research, a descriptive analysis and an inferential analysis of mean differences, Student's *t*-tests and ANOVAs were carried out with variables of gender, school area and each student's last-year performance in Math.

3. Results

This section can be divided by subheadings. It provides a compendious and accurate description of the experimental results, their interpretation and the experimental inferences.
Below, in Table 3, the descriptive results of central tendency (mean and standard deviation) of the items that comprise the Cognitive Process questionnaire are illustrated.

Table 3. Descriptions of sample in Depth Strategy and Self-Regulation Questions.

	N	Mean	Std. Deviation
Item 1. I ask myself questions about the lesson before I start studying.	110	2.31	1.353
Item 2. I think of different ways of solving a problem, and I choose the best.	110	2.98	1.165
Item 3. I go slower when I find important information.	110	3.30	1.231
Item 4. I find my own examples to better understand the information.	110	3.05	1.316
Item 5. I use the structure and organization of the text to better understand.	110	3.22	1.244
Item 6. I constantly wonder whether I will reach my goals.	110	3.49	1.346
Item 7. I think of several ways to solve a problem before I answer it.	110	3.06	1.183
Item 8. When I solve a problem, I wonder if I have taken all options into consideration.	110	3.22	1.184
Item 9. I periodically review to help me understand important mathematical relationships.	110	2.42	1.350
Item 10. When I study, there are times when I pause to see if I understand.	110	3.36	1.353
Item 11. I ask for help when I do not understand something.	110	4.01	1.296
Item 12. When I cannot figure out a math problem, I change the strategies.	110	2.91	1.358
Item 13. When the new information is confusing, I stop and re-examine.	110	3.28	1.235
Item 14. I stop and re-read when I am confused.	110	3.87	1.250
Item 15. When I finish an exam, I know how it went.	110	2.82	1.272
Item 16. When I finish a task, I wonder if there was an easier way to do it.	110	3.09	1.398
Item 17. When I finish studying, I make a summary of what I learned.	110	2.89	1.423
Item 18. When I finish a task, I wonder if I have learned as much as possible.	110	3.31	1.269

Note: Source: own elaboration.

The sample of 110 students participating in this study shows a higher mean in Item 11. Therefore, most of them try to ask for help when they do not understand something, and

the same sample of students shows the lowest mean in Item 1, which depicts the situation in which students ask themselves questions about the lesson before they start studying.

3.1. Results According to Gender

Through the procedure to compare Cognitive Process Questions according to gender by analyzing Student's *t*-tests (n.s = 0.05), the results shown in Table 4 were yielded.

Table 4. Results of the Student's *t*-tests according to gender.

Depth Strategy and Self-Regulation Questions	Gender		Statistical t; *p*-Value [1]	Favorable
	MALE	**FEMALE**		
	N, M (SD)	**N, M (SD)**		
Item 1	80; 2.35 (1.370)	30; 2.20 (1.324)	t = 0.516; *p* = 0.607	not significant
Item 2	80; 3.04 (1.141)	30; 2.83 (1.234)	t = −0.817; *p* = 0.416	not significant
Item 3	80; 3.24 (1.285)	30; 3.47 (1.074)	t = −0.869; *p* = 0.387	not significant
Item 4	80; 2.96 (1.307)	30; 3.27 (1.337)	t = −1.080; *p* = 0.282	not significant
Item 5	80; 3.18 (1.251)	30; 3.33 (1.241)	t = −0.593; *p* = 0.555	not significant
Item 6	80; 3.31 (1.327)	30; 3.97 (1.299)	t = −2.315; *p* = **0.023**	girls > boys
Item 7	80; 2.98 (1.222)	30; 3.30 (1.055)	t = −1.287; *p* = 0.201	not significant
Item 8	80; 3.21 (1.177)	30; 3.23 (1.223)	t = −0.082; *p* = 0.935	not significant
Item 9	80; 2.41 (1.402)	30; 2.43 (1.223)	t = −0.072; *p* = 0.943	not significant
Item 10	80; 3.23 (1.396)	30; 3.73 (1.172)	t = −1.772; *p* = 0.079	not significant
Item 11	80; 4.00 (1.331)	30; 4.03 (1.217)	t = −0.120; *p* = 0.905	not significant
Item 12	80; 2.96 (1.326)	30; 2.77 (1.455)	t = −0.672; *p* = 0.503	not significant
Item 13	80; 3.23 (1.242)	30; 3.43 (1.223)	t = −0.787; *p* = 0.433	not significant
Item 14	80; 3.70 (1.297)	30; 4.33 (0.994)	t = −2.726; *p* = **0.008**	girls > boys
Item 15	80; 2.79 (1.328)	30; 2.90 (1.125)	t = −0.412; *p* = 0.681	not significant
Item 16	80; 2.94 (1.453)	30; 3.50 (1.167)	t = −1.902; *p* = 0.060	not significant
Item 17	80; 2.85 (1.397)	30; 3.00 (1.509)	t = −0.491; *p* = 0.625	not significant
Item 18	80; 3.15 (1.233)	30; 3.73 (1.285)	t = −2.184; *p* = **0.031**	girls > boys

Note: Source: own elaboration. [1] Significant *p* values are in bold, where *p* < 0.05.

In Item 6, children were asked if they constantly wonder if they can reach their goals. This question seems to have stronger meaning for the girls (M = 3.97) of the sample than the boys (M = 3.31), [t (108) = −2.315, *p* = 0.023].

A statistically important result is from Item 14, in which children were asked if they stop and re-read when they are confused. Girls (M = 4.33) gave more importance to this than the boys (M = 3.70), [t (108) = −2.419, *p* = 0.017].

Another statistically significant Item is the 18th, in which children were asked that, when they finish a job, if they wonder if they have learned as much as possible. This question seems to have a more significant impact for the girls (M = 3.73) than the boys (M = 3.15), [t (108) = −2.184, *p* = 0.031].

3.2. Results According to School Area

In addition, by proceeding to compare the Depth Strategy and Self-Regulation Questions according to school area (Appendix A), Student's *t*-tests were analyzed (n.s = 0.05). In Item 9, children were asked if they periodically re-examine something they study, in order to help them understand important relationships. Children who lived in the city

of Heraklion (M = 2.66) seemed to have the habit of periodically re-examining what they study, more than those who live out of the city (M = 2.07), [t (108) = 2.317, *p* = 0.022].

A statistically significant result is from Item 13, in which children were asked if they stop and reconsider when new information is confusing. Children who lived in the city of Heraklion (M = 3.57) seemed to react in the above way more than children who lived out of the city (M = 2.87), [t (108) = 3.042, *p* = 0.003].

3.3. Results According to Students' Last-Year Performances in Math

At this point in the research, to compare the Cognitive Process Questions according to the students' last-year performances in Mathematics (Appendix B), an ANOVA was analyzed (n.s = 0.05).

In this regard, a statistically significant result is from Item 12, in which children gave answers about changing their strategies when they cannot figure out a math problem. This way of thinking of changing strategies represents better children, with last-year performances in Mathematics of 17–18 (M = 3.75) or 13–14 (M = 3.33). Children with last-year performances in math of lower than 10 (M = 2.80), 15–16 (M = 2.77), 11–12 (M = 2.54) or 19–20 (M = 2.11) seemed not to have this kind of routine when they cannot figure out a math problem, [t (5, 104) = 2.451, *p* = 0.038].

There is significance between students with last-year degrees in Mathematics of 15–16 and 19–20 who ask for help when they do not understand something (Item 12). In addition, the difference of the answers given from the students between their last-year grades in mathematics (*p*-value) was calculated for both groups (15–16 and 19–20), and in this case, the value was 0.044, since students with last-year grades in mathematics of 15–16 changed their strategies when they could not figure out a math problem more than those with grades of 19–20 [F (5, 104) = 2.451, *p* = 0.038]. It is essential to mention that the Greek grading scale system for the whole secondary education is between 1 and 20 (1 is the lowest grade, 10 is pass and 20 is perfect).

3.4. Results According to ADHD

To continue with the comparison between Cognitive Process Questions according to other disorders except ADHD (Appendix C), an ANOVA was analyzed (n.s = 0.05). Item 5 depicts children who use the structure and organization of the text to better understand. This question seems to have had a stronger meaning to children with attention-deficit (M = 3.46) and attention-deficit and hyperactivity (M = 3.59) than children with attention-deficit and impulsivity (M = 2.84) and attention-deficit, hyperactivity and impulsivity (M = 2.77), [F (3, 106) = 2.754, *p* = 0.046].

In addition, a statistically important result is from Item 14, in which children with attention-deficit (M = 4.27) and attention-deficit and impulsivity (M = 3.69) stopped and re-read when they were confused. In contrast, children with attention-deficit and hyperactivity (M = 3.59) and attention deficit, hyperactivity and impulsivity (M = 3.23) gave less importance to this [F (3, 106) = 3.524, *p* = 0.018].

In addition, students with attention-deficit stop and re-read when they are confused more than those with attention-deficit, hyperactivity and impulsivity (t = 2.751, *p* = 0.042).

4. Discussion

The use and absence of cognitive and metacognitive strategies has been linked in the past to various learning patterns, such as achievement goals, school performance and the degree of persistence in achieving a given goal [26,27]. However, both cognitive and metacognitive strategies are key self-regulated learning strategies associated with positive learning outcomes [26,28] used by students who use strategies to avoid engaging in dysfunctional behaviors [29,30]. Self-regulatory skills require awareness of how they think in a condition of achievement to control their learning behavior and to maintain a high motivation to achieve. Consequently, help-seeking behaviors as well as academic self-undermining are not expected of students using cognitive and metacognitive strategies.

Seeking help itself is a self-regulatory strategy and an adaptive behavior in response to a subject's own recognition that he or she needs help to achieve a goal [28,30].

A similar study to the one presented in this investigation was carried out by Alci and Karatas (2011) [31], who used the MAI to determine the metacognitive awareness of teacher candidates according to area and sex. They found that, although numerical mastery students had higher results, the differences were not significant. In the same way, men had a higher average, but the difference was not significant either.

In our study, more girls than boys continued to ask if they could reach their goals (self-questioning and self-control) and stopped and re-read when they were confused (self-control and self-regulation). As a result, in this specific area of motivation (self-questioning, self-control and self-regulation) there exists an indifference between girls and boys.

Young and Fry (2008) [10], in their research, applied the MAI to 45 graduate students and 133 undergraduate students and studied the correlation of this instrument with partial and accumulated grades of one of the courses they were taking. They determined that there is a high correlation between the MAI and the cumulative grade point average, as well as with the final grade, and that there are significant differences in the regulation of cognition between undergraduate and graduate students. They state that the MAI is a powerful tool for teachers to know which students need direct instruction on metacognition, especially in large courses or in virtual modes.

In our study, the routine of children of giving answers about changing their strategies when they cannot figure out a math problem (self-regulation) represents better individuals with last-year performances in mathematics, with scores that were mediocre or good. Children in this category ask themselves questions about the lesson before they start studying (voluntary participation in learning with active involvement and utilization of acquired knowledge) and choose the best way of solving a problem, among many different ways (use of adaptive strategies and cultivation of personal identity in learning). Thus, significant indifference exists between students with mediocre or good last-year performances in mathematics and those with different performances in the above. The innovation of Cruz Pichardo and Puentes Puente (2012) [32], on the use of ICT and the teaching of mathematics, indicates that the use of these technological resources in this subject can help the progress of mathematical competence and reorganize their way of thinking, therefore allowing them to develop metacognition strategies.

The results of the current study indicate that most of the children, when they must solve an exercise, firstly try to figure out what this exercise requires, as well as try to ask for help when they do not understand something. In addition, they try to remember some older information when they solve an exercise or understand a text. Moreover, when it seems more important for them to answer a question in a test, they finally read it again to make sure they gave the answer that the question asked.

Children who live in an urban area seem to have the habit of periodically re-examining something they study in order to help them understand important relationships (self-questioning, self-control and self-regulation). Children who live in urban areas seem to stop and reconsider when new information is confusing (self-control and self-regulation) more than children who live out of the city. As a result, there exist significant differences between students depending on their performances in mathematics and their school area. Similarly, the results of the research of Taghieh, Tadayon and Taghieh (2019) [33] indicate significant differences between adolescents from urban and rural areas of Eghlid with respect to cognitive and metacognitive strategies used as learning strategies.

The study of Sibley et al. (2019) [34] indicates that the motivational and the goal-directed features of self-regulated learning are affected in children with ADHD. During this developmental period, group differences are less stable. School-based interventions that emerge for high school students with ADHD may integrate reparative metacognitive strategies, such as goal setting and implementation motives [35].

5. Conclusions

The present research has led to a number of findings concerning the reasons why high school students resort to the use of avoidance behaviors in school, which degrade the learning process and undermine learning outcomes. The findings above lead to the conclusion that self-questioning, self-control as well as self-regulation have a connection with the gender of adolescents. In addition, self-regulation, voluntary participation in learning with the active involvement and utilization of acquired knowledge, the use of adaptive strategies and the cultivation of personal identities in learning represent better individuals with last-year performances in mathematics, with scores that are mediocre or good. Children who live in an urban area have more self-questioning, self-control and self-regulation than those who live out of an urban area. The novelty of the present study lies in the fact that metacognitive factors in relation to mathematical competence were studied exclusively in students with ADHD.

Generalizing the findings of this study is limited, as a convenience sampling procedure was used. It is clear that future research in the field of avoidance behaviors in the school context has much more to contribute, mainly through more holistic and, consequently, more realistic approaches. A more generalized sample can account for both the school context and the family context, which also change in the dynamics of time.

Hence, interventions to improve self-regulated learning among high school students with ADHD may be advanced by targeting metacognition and cognitive flexibility. Despite having several limitations mentioned above, a mathematics curriculum that aims to teach mathematics could use metacognition questioning, self-monitoring and self-evaluating as effective methods.

Appendix A

Table A1. Results of the Student's *t*-tests according to school area.

Depth Strategy and Self-Regulation Questions	School Area		Statistical t; *p*-Value	Favorable
	In the City of Heraklion	Out of the City of Heraklion		
	N, M (SD)	N; M (SD)		
Item 1	65; 2.12 (1.206)	45; 2.58 (1.515)	t = −1.749; p = 0.083	not significant
Item 2	65; 2.85 (1.202)	45; 3.18 (1.093)	t = −1.476; p = 0.143	not significant
Item 3	65; 3.32 (1.213)	45; 3.27 (1.268)	t = −0.235; p = 0.814	not significant
Item 4	65; 3.00 (1.335)	45; 3.11 (1.301)	t = −0.434; p = 0.665	not significant
Item 5	65; 3.23 (1.260)	45; 3.20 (1.236)	t = 0.127; p = 0.899	not significant
Item 6	65; 3.48 (1.359)	45; 3.51 (1.342)	t = −0.130; p = 0.897	not significant
Item 7	65; 3.02 (1.205)	45; 3.13 (1.160)	t = −0.512; p = 0.609	not significant
Item 8	65; 3.25 (1.118)	45; 3.18 (1.284)	t = 0.297; p = 0.767	not significant
Item 9	65; 2.66 (1.372)	45; 2.07 (1.250)	t = 2.317; p = **0.022**	In the city of Heraklion > Out of the city of Heraklion
Item 10	65; 3.28 (1.352)	45; 3.49 (1.359)	t = −0.807; p = 0.422	not significant
Item 11	65; 4.00 (1.287)	45; 4.02 (1.323)	t = −0.088; p = 0.930	not significant
Item 12	65; 2.72 (1.281)	45; 3.18 (1.435)	t = −1.742; p = 0.084	not significant
Item 13	65; 3.57 (1.172)	45; 2.87 (1.217)	t = 3.042; p = **0.003**	In the city of Heraklion > Out of the city of Heraklion
Item 14	65; 3.86 (1.321)	45; 3.89 (1.153)	t = −0.112; p = 0.911	not significant
Item 15	65; 2.91 (1.247)	45; 2.69 (1.311)	t = 0.886; p = 0.378	not significant
Item 16	65; 3.15 (1.460)	45; 3.00 (1.314)	t = 0.566; p = 0.573	not significant
Item 17	65; 2.91 (1.389)	45; 2.87 (1.486)	t = 0.148; p = 0.883	not significant
Item 18	65; 3.31 (1.249)	45; 3.31 (1.311)	t = −0.014; p = 0.989	not significant

Note: Source: own elaboration; Significant *p* values are in bold, where $p < 0.05$.

Appendix B

Table A2. Results of the ANOVA according to students' last-year performances in math.

Depth Strategy and Self-Regulation Questions	Last-Year Performance						Statistical F; *p*-Value	Favorable
	Lower than 10	11–12	13–14	15–16	17–18	19–20		
	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)		
Item 1	10; 2.50 (1.434)	24; 2.25 (1.225)	33; 2.12 (1.386)	26; 2.38 (1.359)	8; 3.00 (1.512)	9; 2.11 (1.453)	F = 0.638; p = 0.672	not significant
Item 2	10; 2.60 (1.430)	24; 2.79 (1.062)	33; 2.85 (1.093)	26; 3.27 (1.041)	8; 3.63 (1.188)	9; 3.00 (1.581)	F = 1.248; p = 0.292	not significant
Item 3	10; 3.80 (1.033)	24; 3.25 (1.189)	33; 3.21 (1.341)	26; 3.46 (1.208)	8; 3.63 (0.744)	9; 2.44 (1.333)	F = 1.474; p = 0.205	not significant
Item 4	10; 3.10 (1.101)	24; 2.71 (1.398)	33; 3.21 (1.409)	26; 3.23 (1.243)	8; 2.75 (1.035)	9; 3.00 (1.500)	F = 0.599; p = 0.701	not significant

Table A2. *Cont.*

Depth Strategy and Self-Regulation Questions	Last-Year Performance						Statistical F; *p*-Value	Favorable
	Lower than 10	11–12	13–14	15–16	17–18	19–20		
	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)	N; M (SD)		
Item 5	10; 3.50 (1.354)	24; 3.04 (0.908)	33; 3.18 (1.261)	26; 3.42 (1.301)	8; 3.00 (1.309)	9; 3.11 (1.764)	F =0.397; *p* = 0.850	not significant
Item 6	10; 3.40 (1.350)	24; 3.33 (1.551)	33; 3.39 (1.456)	26; 3.85 (1.047)	8; 3.25 (1.165)	9; 3.56 (1.424)	F = 0.515; *p* = 0.764	not significant
Item 7	10; 3.20 (1.229)	24; 3.13 (1.154)	33; 2.85 (1.202)	26; 3.27 (1.151)	8; 3.00 (1.309)	9; 3.00 (1.323)	F = 0.413; *p* = 0.839	not significant
Item 8	10; 2.90 (.876)	24; 3.17 (1.049)	33; 3.12 (1.269)	26; 3.69 (1.123)	8; 3.25 (1.165)	9; 2.67 (1.500)	F = 1.453; *p* = 0.212	not significant
Item 9	10; 3.00 (1.563)	24; 2.08 (.929)	33; 2.30 (1.468)	26; 2.92 (1.383)	8; 2.00 (1.195)	9; 2.00 (1.323)	F = 1.835; *p* = 0.112	not significant
Item 10	10; 3.40 (1.578)	24; 3.13 (1.361)	33; 3.55 (1.277)	26; 3.65 (1.294)	8; 3.13 (1.126)	9; 2.67 (1.658)	F = 1.039; *p* = 0.399	not significant
Item 11	10; 4.20 (.919)	24; 4.13 (1.296)	33; 4.03 (1.287)	26; 4.27 (1.151)	8; 3.88 (1.126)	9; 2.78 (1.787)	F = 2.027; *p* = 0.081	not significant
Item 12	10; 2.80 (1.398)	24; 2.54 (1.285)	33; 3.33 (1.429)	26; 2.77 (1.177)	8; 3.75 (1.282)	9; 2.11 (1.269)	F = 2.451; *p* = **0.038**	17-18 > 13-14 > lower than 10 > 15-16 > 11-12 > 19-20
Item 13	10; 3.30 (1.160)	24; 3.42 (1.060)	33; 3.12 (1.409)	26; 3.69 (0.970)	8; 3.13 (1.356)	9; 2.44 (1.424)	F = 1.644; *p* = 0.155	not significant
Item 14	10; 3.90 (1.449)	24; 3.75 (1.152)	33; 3.73 (1.526)	26; 4.35 (0.629)	8; 3.38 (1.188)	9; 3.78 (1.481)	F = 1.155; *p* = 0.336	not significant
Item 15	10; 2.90 (1.524)	24; 2.75 (1.391)	33; 3.09 (1.182)	26; 2.69 (1.289)	8; 2.88 (1.126)	9; 2.22 (1.093)	F = 0.766; *p*= 0.576	not significant
Item 16	10; 3.20 (1.476)	24; 2.96 (1.459)	33; 3.30 (1.425)	26; 3.23 (1.366)	8; 3.00 (0.926)	9; 2.22 (1.481)	F =0.959; *p* = 0.447	not significant
Item 17	10; 2.80 (1.476)	24; 2.58 (1.501)	33; 2.82 (1.402)	26; 3.38 (1.203)	8; 3.13 (1.458)	9; 2.44 (1.740)	F = 1.101; *p* = 0.364	not significant
Item 18	10; 3.20 (1.476)	24; 3.42 (1.349)	33; 3.30 (1.311)	26; 3.42 (1.065)	8; 3.13 (1.126)	9; 3.00 (1.581)	F = 0.224; *p* = 0.952	not significant

Note: Source: own elaboration; Significant *p* values are in bold, where $p < 0.05$.

Appendix C

Table A3. Results of the ANOVA according to ADHD.

Depth Strategy and Self-Regulation Questions	ADHD				Statistical F; *p*-Value	Favorable
	AD [1]	ADH [2]	ADI [3]	ADHI [4]		
	N; M (SD)	N; M (SD)	N, M (SD)	N, M (SD)		
Item 1	48; 2.35 (1.436)	17; 2.35 (0.996)	32; 2.47 (1.391)	13; 1.69 (1.316)	F = 1.075; *p* = 0.363	not significant
Item 2	48; 2.98 (1.229)	17; 3.35 (0.996)	32; 2.94 (1.243)	13; 2.62 (0.870)	F = 1.020; *p* = 0.387	not significant
Item 3	48; 3.40 (1.284)	17; 3.18 (1.334)	32; 3.41 (1.073)	13; 2.85 (1.281)	F = 0.819; *p* = 0.486	not significant
Item 4	48; 3.04 (1.220)	17; 3.24 (1.522)	32; 3.03 (1.257)	13; 2.85 (1.625)	F = 0.214; *p* = 0.887	not significant

Table A3. *Cont.*

Depth Strategy and Self-Regulation Questions	ADHD				Statistical F; *p*-Value	Favorable
	AD [1]	ADH [2]	ADI [3]	ADHI [4]		
	N; M (SD)	N; M (SD)	N, M (SD)	N, M (SD)		
Item 5	48; 3.46 (1.220)	17; 3.59 (1.228)	32; 2.84 (1.221)	13; 2.77 (1.166)	F = 2.754; *p* = **0.046**	ADH > AD > ADI > ADHI
Item 6	48; 3.85 (1.130)	17; 3.00 (1.500)	32; 3.38 (1.343)	13; 3.08 (1.656)	F = 2.508; *p* = 0.063	not significant
Item 7	48; 3.15 (1.255)	17; 2.94 (1.029)	32; 3.13 (1.264)	13; 2.77 (.927)	F = 0.428; *p* = 0.733	not significant
Item 8	48; 3.56 (1.165)	17; 3.12 (1.317)	32; 2.97 (1.031)	13; 2.69 (1.182)	F = 2.862; *p* = 0.040	not significant
Item 9	48; 2.44 (1.443)	17; 2.59 (1.372)	32; 2.53 (1.270)	13; 1.85 (1.144)	F = 0.944; *p* = 0.422	not significant
Item 10	48; 3.65 (1.296)	17; 2.88 (1.317)	32; 3.25 (1.391)	13; 3.23 (1.423)	F = 1.554; *p* = 0.205	not significant
Item 11	48; 4.19 (1.266)	17; 3.88 (1.409)	32; 3.94 (1.216)	13; 3.69 (1.494)	F =0.643; *p* = 0.589	not significant
Item 12	48; 2.98 (1.376)	17; 3.29 (1.359)	32; 2.69 (1.306)	13; 2.69 (1.437)	F = 0.890; *p* = 0.449	not significant
Item 13	48; 3.58 (1.182)	17; 3.24 (1.348)	32; 2.88 (1.185)	13; 3.23 (1.235)	F = 2.196; *p* = 0.093	not significant
Item 14	48; 4.27 (1.026)	17; 3.59 (1.228)	32; 3.69 (1.281)	13; 3.23 (1.589)	F = 3.524; *p* = **0.018**	AD > ADI > ADH > ADHI
Item 15	48; 2.69 (1.240)	17; 3.29 (1.263)	32; 2.91 (1.304)	13; 2.46 (1.266)	F = 1.368; *p* = 0.257	not significant
Item 16	48; 3.17 (1.342)	17; 3.24 (1.562)	32; 2.84 (1.439)	13; 3.23 (1.363)	F = 0.477; *p* = 0.699	not significant
Item 17	48; 3.04 (1.458)	17; 2.71 (1.213)	32; 2.91 (1.445)	13; 2.54 (1.561)	F = 0.536; *p* = 0.659	not significant
Item 18	48; 3.60 (1.162)	17; 3.41 (1.228)	32; 2.97 (1.402)	13; 2.92 (1.188)	F = 2.136; *p* = 0.100	not significant

Note: Source: own elaboration; Significant *p* values are in bold, where $p < 0.05$; [1] AD = attention-deficit, [2] ADH = attention deficit and hyperactivity, [3] ADI = attention deficit and impulsivity and [4] ADHI = attention-deficit, hyperactivity and impulsivity.

References

1. Polanczyk, G.V.; Willcutt, E.G.; Salum, G.A.; Kieling, C.; Rohde, L.A. ADHD prevalence estimates across three decades: An updated systematic review and meta-regression analysis. *Int. J. Epidemiol.* **2014**, *43*, 434–442. [CrossRef] [PubMed]
2. Pelham, J.W.; Fabiano, G.A.; Massetti, G.M. Evidence-based assessment of attention deficit hyperactivity disorder in children and adolescents. *J. Clin. Child Adolesc. Psychol.* **2005**, *34*, 449–476. [CrossRef] [PubMed]
3. Scholtens, S.; Rydell, A.-M.; Yang-Wallentin, F. ADHD symptoms, academic achievement, self-perception of academic competence and future orientation: A longitudinal study. *Scand. J. Psychol.* **2013**, *54*, 212. [CrossRef] [PubMed]
4. Kannass, K.N.; Colombo, J.; Wyss, N. Now, pay attention! The effects of instruction on children's attention. *J. Cognit. Dev.* **2010**, *11*, 509–532. [CrossRef] [PubMed]
5. Negretti, R. Metacognition in student academic writing: A longitudinal study of metacognitive awareness and its relation to task perception, self-regulation, and evaluation of performance. *Writ. Commun.* **2012**, *29*, 142–179. [CrossRef]
6. Institute of Medicine and National Research Council. *Transforming the Workforce for Children Birth Through Age 8: A Unifying Foundation*; The National Academies Press: Washington, DC, USA, 2015. [CrossRef]
7. Akın, A. *Güncel Psikolojik Kavramlar 1: Pozitif Psikoloji*; Sakarya Üniversitesi Egitim Bilimleri Enstitüsü: Sakarya, Turkey, 2013.
8. Schraw, G.; Dennison, R. Assessing metacognitive awareness. *Contemp. Educ. Psychol.* **1994**, *19*, 460–475. [CrossRef]
9. Narang, D.; Saini, S. Metacognition and Academic Performance of Rural Adolescents. *Stud. Home Community Sci.* **2013**, *7*, 167–175. [CrossRef]
10. Young, A.; Fry, J. Metacognitive awareness and academic achievement in college students. *J. Scholarsh. Teach. Learn.* **2008**, *8*, 1–10.
11. Directive 2018/C189/1/EU of the European Parliament of the Council of 22 May 2018 on Council Recommendation on Key Competences for Lifelong Learning (Text with EEA Relevance). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01) (accessed on 22 May 2018).

12. Berch, D.B.; Geary, D.C.; Mann Koepke, K. Development of mathematical cognition. In *Neural Substrates and Genetic Influences*; Academic Press: San Diego, CA, USA, 2015; Volume 2. [CrossRef]

13. Geary, D.C.; Moore, A.M. Cognitive and brain systems underlying early mathematical development. *Prog. Brain Res.* **2016**, *227*, 75–103. [CrossRef]

14. Vanbinst, K.; De Smedt, B. Individual differences in children's mathematics achievement: The roles of symbolic numerical magnitude processing and domain-general cognitive functions. *Prog. Brain Res.* **2016**, *227*, 105–130. [CrossRef]

15. Vo, V.A.; Li, R.; Kornell, N.; Pouget, A.; Cantlon, J.F. Young children bet on their numerical skills: Metacognition in the numerical domain. *Psychol. Sci.* **2014**, *25*, 1712–1721. [CrossRef] [PubMed]

16. Kramarski, B.; Mevarech, Z.R.; Arami, M. The effects of metacognitive instruction on solving mathematical authentic tasks. *Educ. Stud. Math.* **2002**, *49*, 225–250. [CrossRef]

17. Mayes, S.D.; Calhoun, S.L. Frequency of reading, math, and writing disabilities in children with clinical disorders. *Learn. Individ. Differ.* **2006**, *16*, 145–157. [CrossRef]

18. Arnold, L.E.; Hodgkins, P.; Kahle, J.; Madhoo, M.; Kewley, G. Long-term outcomes of ADHD: Academic achievement and performance. *J. Atten. Disord.* **2020**, *24*, 73–85. [CrossRef] [PubMed]

19. Law 3699/2008, Article 4, Special Education and Training of People with Disabilities or Special Educational Needs, Government Gazette of the Hellenic Republic (FEK 199/A/2-10-2008). Available online: https://www.et.gr/idocs-nph/search/pdfViewerForm.html?args=5C7QrtC22wHtyK1ZYNhP8HdtvSoClrL8Rc9TCA8iZVd5MXD0LzQTLWPU9yLzB8V68knBzLCmTXKaO6fpVZ6Lx3UnKl3nP8NxdnJ5r9cmWyJWelDvWS_18kAEhATUkJb0x1LIdQ163nV9K--td6SIuYHpDLru_jp1nHYxUFkpCZw_KLwy_NL6gizOSKGusZdE (accessed on 2 October 2018).

20. Law 4186/2013, Article 28, Par. 21, Restructuring of Secondary Education and other provisions, Government Gazette of the Hellenic Republic (FEK 193/A/17-9-2013). Available online: http://elib.aade.gr/elib/view?d=/gr/act/2013/4186/art/16/para/2%CE%91 (accessed on 17 September 2013).

21. Wu, Z.; Chen, Z.; Chen, G.; Li, X.; Jiang, C.; Gan, X.; Gao, L.; Wang, S. A probability feasible region enhanced important boundary sampling method for reliability-based design optimization. *Struct. Multidiscip. Optim.* **2021**, *63*, 341–355. [CrossRef]

22. Law 2472/1997, article 2, Protection of Individuals with regard to the Processing of Personal Data, European Union Agency for Fundamental Rights, Government Gazette of the Hellenic Republic (FEK A-50/10-4-1997). Available online: http://www.et.gr/idocs-nph/search/pdfViewerForm.html?args=5C7QrtC22wEWFzYWFtEvQndtvSoClrL8J6SqjdSFK_HtIl9LGdkF53UIxsx942CdyqxSQYNuqAGCF0IfB9HI6qSYtMQEkEHLwnFqmgJSA5WIsluV-nRwO1oKqSe4BlOTSpEWYhszF8P8UqWb_zFijKsLM8XD-SIYwIjpKpw3g_Bqh23LG_p9TXYFWiYDtT8H (accessed on 10 April 2022).

23. General Assembly resolution 44/25/1989, article 3 and 12, Convention on the Rights of the Child, United Nations, Human Rights, Office of the High Commissioner. Available online: https://www.ohchr.org/en/resources/educators/human-rights-education-training/7-convention-rights-child-1989 (accessed on 20 November 2021).

24. Huertas, A.P.; Vesga, G.J.; Galindo, M. Validacion del Instrumento 'Inventario de Habilidades Metacognitivas (MAI)' con Estudiantes Colombianos. *Prax. Saber* **2014**, *5*, 55–74. [CrossRef]

25. Field, A. *Discovering Statistics Using SPSS*; Sage Publication: London, UK, 2009.

26. McWhaw, K.; Abrami, P.C. Student goal orientation and interest: Effects on students' use of self-regulated learning strategies. *Contemp. Educ. Psychol.* **2002**, *26*, 321–329. [CrossRef]

27. Pintrich, P.R.; Wolters, C.; Baxter, G. Assessing metacognition and self-regulated learning. In *Issues in the Measurement of Metacognition*; Schraw, G., Impara, J., Eds.; The University of Nebraska Press: Lincoln, NE, USA, 2000; pp. 43–97.

28. Karabenick, S.A.; Dembo, M.H. Understanding and facilitating self-regulated help seeking. *New Dir. Teach. Learn.* **2011**, *126*, 33–43. [CrossRef]

29. Petersen, L.E. Self-compassion and self-protection strategies: The impact of self-compassion on the use of self-handicapping and sandbagging. *Pers. Individ. Differ.* **2014**, *56*, 133–138. [CrossRef]

30. Thomas, C.R.; Gadbois, S.A. Academic self-handicapping: The role of self-concept clarity and students' learning strategies. *Brit. J. Educ. Psychol.* **2007**, *77*, 101–119. [CrossRef]

31. Alci, B.; Karatas, H. Teacher candidates' metacognitive awareness according to their domains and sex. *Int. J. Multidiscip. Thought* **2011**, *1*, 255–263.

32. Cruz Pichardo, I.M.; Puente, A.P. Innovación educativa: Uso de las TIC en la enseñanza de la Matemática básica. *Edmetic* **2012**, *1*, 127–145. [CrossRef]

33. Taghieh, M.R.; Tadayon, Z.; Taghieh, R. Comparison of cognitive and metacognitive strategies in the academic achievement of urban and rural students of Eghlid. *IJERI Int. J. Educ. Res. Innov.* **2019**, *12*, 282–293. [CrossRef]

34. Sibley, H.M.; Graziano, A.P.; Mercedes, O.; Rodriguez, L.; Coxe, S. Academic impairment among high school students with ADHD: The role of motivation and goal-directed executive functions. *J. Sch. Psychol.* **2019**, *77*, 67–76. [CrossRef]

35. Gawrilow, C.; Morgenroth, K.; Schultz, R.; Oettingen, G.; Gollwitzer, P.M. Mental contrasting with implementation intentions enhances self-regulation of goal pursuit in schoolchildren at risk for ADHD. *Motiv. Emot.* **2013**, *37*, 134–145. [CrossRef]