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MATH ANXIETY IN PRIMARY SCHOOL STUDENTS: ASSESSMENT AND COGNITIVE TUTORING

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Annex 1 - statement attached to the doctoral thesis

(1) Andreea Ioana Petruț hereby certifies that:

(a) The thesis includes the original research work of PhD student Andreea Ioana Petruț (author)

(b) Parts of the thesis have already been published or submitted for publication; citations for these publications have been included in the thesis. Other co-authors were included in the publications, if they contributed to the exposition of the published text, data interpretation, etc. (the contribution was clearly explained in the thesis footnotes);

(c) The thesis has been written according to academic writing standards (eg, appropriate scientific acknowledgments and in-text citations have been made by the thesis authors). All the text of the thesis and its summary were written by Andreea Ioana Petruț, who assumes all responsibilities for academic writing; also:

- Software was used to check academic writing (see: http://www.plagiarismdetector.com/); the thesis passed the critical test;
- A copy of the dataset/research database has been delivered to the Department/Doctoral School (electronically).

Date: Drd. candidate: Andreea Ioana Petruț

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CHAPTER I. THEORETICAL FRAMEWORK

1.1. Introduction and Research Motivation

Mathematics helps us to have orderly and balanced lives. Certain qualities such as creativity, critical thinking, spatial vision and problem-solving skills are developed by mathematical thinking. So far, there are many studies investigating math anxiety in adolescent and adult populations (e.g. Hembree, 1990; Ma, 1999; Ashely and Ridley, 2005, Anbar and Visu-Petra, 2022), but the number of studies that have addressed mathematics anxiety among primary and secondary school pupils is much smaller. Also, many of the findings among pupils are inconsistent in that some studies claim that girls are prone to math anxiety while boys are naturally gifted in math (Tapia and Marsh, 2004; Bieg, Goetz, Wolter, & Hall, 2015; Soni & Kumari, 2017; Fernandez, Froschl, Lorenzetti, & Stimmer, 2022), other studies argue that the involvement of anxious parents in homework completion increases the likelihood of children developing math anxiety over time (Maloney et al. 2015) and others argue that parental involvement positively predicts children's performance in subjects such as mathematics (Gonzalez and Wolters, 2006).

Given these aspects, in the present work we will focus on math anxiety among the populations of children in primary and secondary classes. Specifically, we will focus on the relationship between math anxiety and other relevant related constructs, such as test anxiety, generalized anxiety, working memory, and the impact that math anxiety has on math achievement.[1]

In recent years, researchers have turned their attention to an under-researched topic, that of the negative effects that math anxiety can have on school performance in mathematics (Núñez-Peña, Suárez-Pellicioni, & Bono, 2013; Suárez-Pellicioni, Núñez-Peña, María, & Colomé, 2016; Petruț & Visu-Petra, 2020). The increased interest in investigating math anxiety can be explained by a number of needs such as:

[1] The content of subchapter 1.1. is part of the manuscript entitled Self-reported Mathematics Anxiety: Conceptual and psychometric considerations, published by the authors Petruț, A., & Visu-Petra, L., in the year (2020), in the journal: Journal of Psychology, 66 (3), 259- 279.

(1) the need to identify factors that influence the manifestation of math anxiety (Rubinsten et al. 2015);

(2) the need to investigate the relationship between math anxiety, trait anxiety, and test anxiety (Kazelskis, Reeves, et al. 2001; Jiang, Sato, Hara, Takedomi, Ozaki, & Yamada, 2003; Devine et al. 2012; Edwards, Edwards, and Lyvers, 2017; Weger and Sandi 2018) and

(3) the need to investigate the mechanisms underlying below-average school performance of children with high math anxiety (Wigfield and Meece, 1988; Mier-Van, Scheleepen, and Berg - Van, 2019) in order to implement cognitive tutoring programs in schools to remediate math anxiety while leading to improved math performance both in and out of school (Petruț and Visu-Petra, 2020).

1.2. The relevance of the research[2]

Mathematical skills are important for both the academic or professional field and for everyday life situations (Ashcraft, 2002; Ashcraft and Moore, 2006; Dower, 2016, Anbar and Visu-Petra, 2022). However, a significant percentage of the population reports anxiety and emotional distress when faced with mathematical stimuli (Ashcraft and Kirk, 2001). According to statistical estimates, it seems that about 20% of the population experiences anxiety symptoms when solving mathematical tasks or when operating with numerical information (Ashcraft and Kirk, 2001; Ashcraft, 2002; Ashcraft and Moore, 2006; Dowker, 2016). Studies investigating math anxiety show that as children progress through their education, math anxiety increases and peaks around the ninth grade (e.g., Hembree, 1990).

These reactions to mathematical stimuli are known in the literature as math anxiety. Math anxiety, is often defined as "a feeling of tension and anxiety that interferes with manipulating numbers and solving mathematical problems in academic or everyday life situations" (Richardson & Suinn, 1972, p .551). Individuals with math anxiety may have different reactions when confronted with mathematical stimuli (Ashcraft, 2002). These reactions can range from low intensity reactions to high intensity reactions (Ashcraft, 2002; Ashcraft, 2009).

[2] Part of sub-chapter 1.2. is part of the article Self-reported Mathematics Anxiety: Conceptual and psychometric considerations, by authors Petruț, A., & Visu-Petra, L., (2020) in Revista de Psihologie, 66 (3), 259- 279.

Also, studies show that these reactions are not circumscribed to a certain setting: math anxiety can appear both in formal contexts (e.g. a math test) but also in everyday situations (e.g. recalculating a bill at a restaurant) according to Ashcraft, (2002).

For a more complex analysis, we can approach the characteristics of math anxiety at the following three levels (a) cognitive characteristics: cognitions and thoughts of worry about current or future assessment situations, specifically fears about the possibility of being evaluated negatively by peers or teachers based on current (e.g., solving a math exercise on the board) or future (e.g., being called to give an answer) performance (Ashcraft et al. 2007; Hopko, McNeil, Zvolensky, & Eifert, 2001; Wheaton, Braddock, & Abramowitz, 2011), (b) behavioral characteristics (e.g., avoidance behaviors) (Hembree, 1990; Ashcraft & Faust, 1994; Chipman, Krantz, & Silver, 1992), and (c) physiological characteristics (e.g. increased heart rate, dizziness, etc., Dew, Galassi, & Galassi, 1984).

Math anxiety can have a negative impact on the educational trajectory (Ashcraft, Kirk, & Hopko, 1998). It appears that people with math anxiety report less enjoyment of the subject, lack confidence in their potential to learn math, and are less likely to be exposed to math stimuli or problem solving situations, math exercises and problems (e.g. avoid math classes) (Ashcraft & Kirk, 1998; Maloney & Beilock, 2012). All of these can have a snowball effect, with both short-term and long-term consequences (Hembree, 1990). In the short term, people with math anxiety deprive themselves of the opportunity to build math skills, thereby perpetuating negative beliefs about themselves and the prospect of doing math (Hembree, 1990). In terms of long-term effects, these people, due to the fact that they have avoided building their mathematical skills, may be rejected in admissions sessions to realistic profile high schools or faculties and may avoid certain professions or higher education altogether (e.g. Hembree, 1990).

According to Ashcraft (2002, 2019) math anxiety is a complex phenomenon with broad etiology and numerous negative consequences. Its negative impact affects people of different ages, being often associated with lower performance in mathematics and a negative attitude towards mathematics. Math anxiety refers to the fear or tension that many people feel when dealing with mathematics (Ashcraft, 2002). Math anxiety has also been shown to produce physiological changes in heart rate, neural activity, and cortisol levels (Lyons & Beilock, 2012; Young, Wu, & Menon, 2012; Sarkar, Dowker, & Cohen, 2014; Pletzer , Kronbichler, Nuerk, & Kerschbaum, 2015).

Maloney and Beilock (2012) believe that mathematical skills are important for school success and in everyday life. People who experience fears and anxieties when they have to solve math problems show math anxiety. For these individuals, confronting math comes with a negative emotional response, meaning that math anxiety is an adverse emotional reaction to math or the prospect of doing math.

Mathematics anxiety can be seen as a personality construct, i.e. that dimension of personality which is characteristic of both general and test anxiety and which has been studied in relation to other characteristics such as attitudes, learning, avoidance, motivation; or as a socio-cultural construct (socio-cultural factors that influence an individual's math anxiety); as a neuro-biological construct (brain activation during math task solving and genetic factors); or as a cognitive construct that refers to the conscious internal process of worry during the anxious reaction and consumes working memory resources (Ashcraft, 2019).

Ashcraft (2002, p. 1) defines math anxiety as "a feeling of tension, fear, apprehension, and restraint that interferes with math performance" experienced by people when they engage in math problem solving and can be observed more easily in situations that involve examining students' mathematical abilities (Ashcraft, 2002, Ramirez, Shau, & Maloney, 2018).

The first studies on math anxiety date back to the 1950s, when Mary Fides Gough (cited by Ascraft 2002) first used the term math phobia (eg *mathemaphobia*) to describe math anxiety or feelings of fear against mathematics. The first scale to measure math anxiety was developed by Richardson and Suinn in 1972 (cited by Suárez-Pellicioni, Núñez-Peña, Colomé, Àngels 2016) which led to the start of empirical studies examining math anxiety (Hembree , 1990; Aschraft, 2002).

In the meta-analysis by Zhang, Zhao and Kong (2019), studies conducted between 2000 and 2019 were analyzed (84 samples, N = 8680). In these studies, the relationship between math anxiety and math achievement was investigated. The results indicated a strong negative relationship between math anxiety and math performance. Regarding the analysis of moderator variables, a strong negative relationship was observed between mathematics anxiety in high school students and problem solving skills, especially in Asian students. A weaker negative association was noted in studies involving European primary and secondary school students (Zhang, Zhao, & Kong, 2019).

In another meta-analysis by Hembree (1990) of 151 studies, it was noted that math anxiety

is related to poor performance on mathematics tests and negative and avoidant attitude towards mathematics. It was found that students who showed a high level of math anxiety avoided situations that required the performance of mathematical calculations, something also found by Ashcraft (2002). Avoiding exposure to practical situations involving mathematics resulted in reduced mathematics skills and knowledge in students with math anxiety. Therefore, the poor results of students with math anxiety can be attributed to math anxiety or lack of math skills (Ma, 1999; Anbar and Visu-Petra, 2022).

1.2.1. Explanatory Theories of Mathematics Anxiety

Most of the studies that address the problem of math anxiety relate it to academic performance in mathematics, starting from three theories:

1. Cognitive interference theory, which claims that anxiety causes individuals to perform poorly in mathematics by affecting working memory resources, known as the disruption account. Poor school performance in mathematics is the cause of reduced cognitive resources for solving mathematical problems and by inducing negative emotions and rumination (Ashcraft and Kirk, 2001; Erturan and Jansen, 2015; Pizzie and Kraemer, 2017; Pizzie and Kraemer, 2017; Ramirez, Shaw and Maloney, 2018).

2. The theory of reduced competence (eng. reduced competence account) refers to the fact that low mathematical skills are the ones that underlie math anxiety. Students with low math skills avoid math (eg they don't do their homework, skip math classes, etc.) and thus fall behind in the subject and end up with low performance (Hembree, 1990).

Although the two theories seem to be at odds, the consensus among researchers is that there is a bidirectional relationship between math anxiety and math achievement (Carey et al. 2015).

3. The interpretive theory (eng. interpretation account, Ramirez, Shaw and Maloney, 2018): according to which students end up developing math anxiety due to the interpretations they make of their experiences and results in mathematics. These interpretations can be influenced by: cultural stereotypes (Biex et al. 2015), societal beliefs about learning disabilities (Benjamin, Bjork, & Schwartz, 1998; Stigler & Hiebert, 2004), social interactions at home (Maloney et al. 2018) or

in the classroom (Beilock et al. 2010), the teacher's teaching style (Ramirez et al. 2018), or the poor attribution of physiological activation level (Jamieson et al. 2012).

The low-skills and interpretive theories are at odds: the low-skills theory is supported by longitudinal studies of children with math learning disabilities, and the interpretive is supported by research that manipulates anxiety levels and observes a change in math performance (Ashcraft and Kirk, 2001; Carey et al. 2015). Merging the two theories through the mixture of arguments could indicate a bidirectional relationship between math performance and math anxiety leading to the formulation of a new theory, namely the theory of reciprocity. This is based on the interdependence between math anxiety and math performance, which can influence each other in a vicious circle.

To date, research has focused primarily on the consequences of math anxiety. Its antecedents, however, remain largely unexplored. In this sense we found that only a small number of studies investigated mathematics anxiety from the perspective of a dependent variable (Jain and Dowson, 2009). However, although information on the development of math anxiety is scarce, it is hypothesized that math anxiety would be a multifactorial construct.

In conclusion, math anxiety interferes with the ability to solve math problems in both every day and academic situations (Richardson & Suinn, 1972; Ramirez, Shau, & Maloney, 2018) and is accompanied by a response emotionally negative in situations involving solving mathematical problems (Ashcraft, 2002).

Considering the negative effects of math anxiety, we consider necessary finding solutions to reduce it. As a pervasive problem in education, it requires attention from both teachers and researchers to help students achieve academic achievement in mathematics (Maloney and Beilock 2012; Jansen, Louwerse, Straatemeier, Van der Ven, Klinkenberg, & Van der Maas, 2013; Ramirez, Shau, & Maloney, 2018).

Math anxiety is a phenomenon that has been recorded globally. Although there are various ways to measure mathematics anxiety, one obvious finding is that it is increasingly prevalent in schools (Hembree, 1990; Ma, 1999; Eden, Heine, & Jacobs, 2013; Zhang, Zhao, & Kong, 2019). In the United States, according to studies cited by Chang and Beilock, (2016) approximately 25% of fourth grade students exhibit math anxiety and up to 80% of high school students reported

moderate to high levels of math anxiety. Mathematics according to the Canadian Educational Research Association cited by Hyesang and Beilock (2016).

Of the 65 countries that participated in the Program for International Student Assessment (PISA) in 2012, 33% of 15-year-old students reported feelings of helplessness in situations that involved solving mathematical problems (according to the Organization for Economic Co-operation and Development [OECD], 2013).

80% of Romanian students reported concern about the mathematical discipline according to the Report of the Organization for Economic Cooperation and Development [OECD], 2013.

In 2018, Romania was on the 52nd place in the ranking of mathematics results in the PISA 2018 test, after Bulgaria, according to the [OECD] Report, 2018, being ranked last in the European Union, surpassed even by Bulgaria with the lowest ranking so far in the PISA tests.

In 2022, Romania was on the 51st place, being second to last before Bulgaria in the ranking. The OECD report shows that compared to the 2015 PISA testing, weaker students became even weaker in PISA 2018 results in mathematics and science. At the same time, there is no change regarding the students with good performances.

Romania has the worst results in the last 9 years in the PISA tests. The score obtained is decreasing compared to the last two tests in which Romania participated (2012 and 2015) in all three areas tested: reading, mathematics and science, according to the PISA 2018 results published by [OECD], 2018. The percentage of functional illiteracy is 44%, on average, up from 2015 and 2012.

The PISA results show the lack of efficiency of the Romanian education system and in this sense politicians, teachers and researchers could blame the education system, but another source that should share this blame is our math-phobic culture (Burns, 1998; Chew and Dillon, 2014).

1.3. The Relationship Between Mathematics Anxiety and Other Related Constructs

Math anxiety has been investigated in relation to other relevant constructs such as test anxiety, generalized anxiety, cognitive variables such as working memory (Mammarella, Hill, Devine, Caviola, & Szűcs, 2015), as well as different academic variables, related to mathematical performance (e.g. Hembree, 1990; Ashcraft, 2002; Ashcraft and Moore, 2006; Dower, 2016). However, the vast majority of these studies were conducted on adolescent and adult populations,

the number of studies conducted on pupils being small, and the results obtained inconclusive (Ashcraft, 2002; Ashcraft and Moore, 2006; Dower, 2016). In the next section we will try to summarize the results of the studies that have investigated math anxiety in children and the links that mathematics anxiety has with other constructs.

Behavioral and psychophysiological research by Chang and Beilock (2016) reveals that the link between math performance and math anxiety is related to both individual (cognitive, affective/physiological, motivational) and environmental (social/contextual) factors.

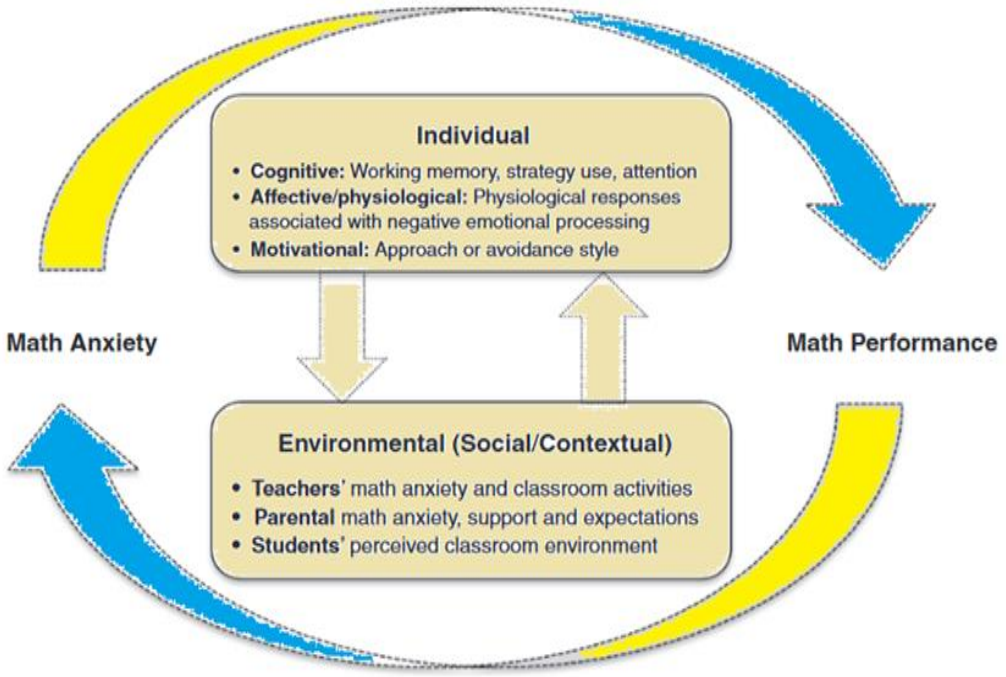


Figure 1. *Individual and environmental factors in the reciprocal relationship between anxiety versus mathematics and performance (Chang and Beilock, 2016)*

Based on the finding that individuals with high or moderate levels of math anxiety avoid situations involving math, generally perform poorly on standardized math tests, have difficulty solving math problems (Hambree, 1990), perform poorly on operations involving numerical reasoning and difficulties in basic numerical processing (Maloney, 2011, 2013).

CHAPTER II. RESEARCH OBJECTIVES AND GENERAL METHODOLOGY

2.1. Theoretical objectives

The present thesis extends the existing literature on mathematics anxiety in several directions. For the first time, to our knowledge, a theoretical review of scales measuring math anxiety has been conducted. Also, from a theoretical point of view, we have managed to carry out a theoretical review and a classification of the existing mathematical cognitive tutoring programs up to the present time, with special interest given to the computerized cognitive tutoring programs. The conclusions of these theoretical analyzes were the basis for the creation and theoretical structuring of a mathematical cognitive tutoring program for primary school students.

The main practical objectives included:

(1) Validation of two math anxiety scales for primary school students (Modified Abbreviated Math Anxiety Scale (mAMAS) and Early Math Anxiety Scale (SEMA). Identifying those factors that have been confirmed in other present studies in specialized literature.

At the same time, the work also focuses on:

(2) Capturing the relationship between math anxiety in elementary school students and its relationship with test anxiety, trait anxiety, school attitude, and teacher attitude; Exploring gender differences in both math anxiety and test anxiety; surprising the relationship between math anxiety and test anxiety and student mathematics achievement.

(3) Investigating the relationship between math anxiety and test anxiety among elementary and middle school students. Exploring the effects of gender and age (grades 2–4 and longitudinally 5–7, respectively) on both math anxiety and test anxiety; investigating the relationship between math anxiety, parents' involvement in homework and students' results in mathematics. The evolution over three years (2019-2021/2022) of math anxiety in children and parents through a study based on repeated measurements; to capture the three-year evolution (2019-2021/2022) of math anxiety in children and parents through a larger study based on repeated measures.

(4) Testing the effectiveness of a new cognitive tutoring program on math skills and math anxiety in elementary school students.

In accordance with aim 4, we tested a complex computer program for cognitive training of children. At the same time, in order to fulfill objectives (1), (2) and (3) we have carried out and published studies focused on the relationship between anxiety and the mentioned constructs.

2.2. Methodological and/or Practical Objectives

The main major contribution is to provide landmark results in the school field through new data and practical arguments and theoretical evidence that confirm the destructive effects of math anxiety on students' academic success in mathematics and the effectiveness of computerized cognitive tutoring interventions on math anxiety. Through four studies including: adapting instruments to measure math anxiety and finding the most appropriate methods to investigate early signs of math anxiety in children

(1) investigating related constructs such as trait anxiety, test anxiety, math achievement, class, gender differences, and math achievement

(2) investigating the relationship between parent and child math anxiety (Patall, Cooper, & Robinson, 2008) and parental factors such as homework involvement and predictors of math anxiety

(3) The latest study aims to develop and implement a pilot cognitive tutoring program designed to improve math anxiety and increase math performance in children with high levels of math anxiety

(4) The presented research proposal will make significant methodological, empirical and conceptual contributions related to the emergence and development of math anxiety in relation to math performance in primary school children. Using a longitudinal design (Prinzie and Onghena, 2005) can generate a complex picture of the interrelationships between the early development of math anxiety and trait anxiety in an ontogenetic period marked by substantial developments in all these dimensions. This will generate a deep understanding of the proposed causal influences between these variables. Study design and piloting - the proposed cognitive tutoring program, yields new findings regarding the negative relationship between math achievement and math anxiety. Presented as a series of games for successive discovery of 8 planets in an intensive 4-week cognitive tutoring program following the model used by Superkar et al. (2015) with lessons of increasing difficulty (addition, subtraction, multiplication, division and complex operations).

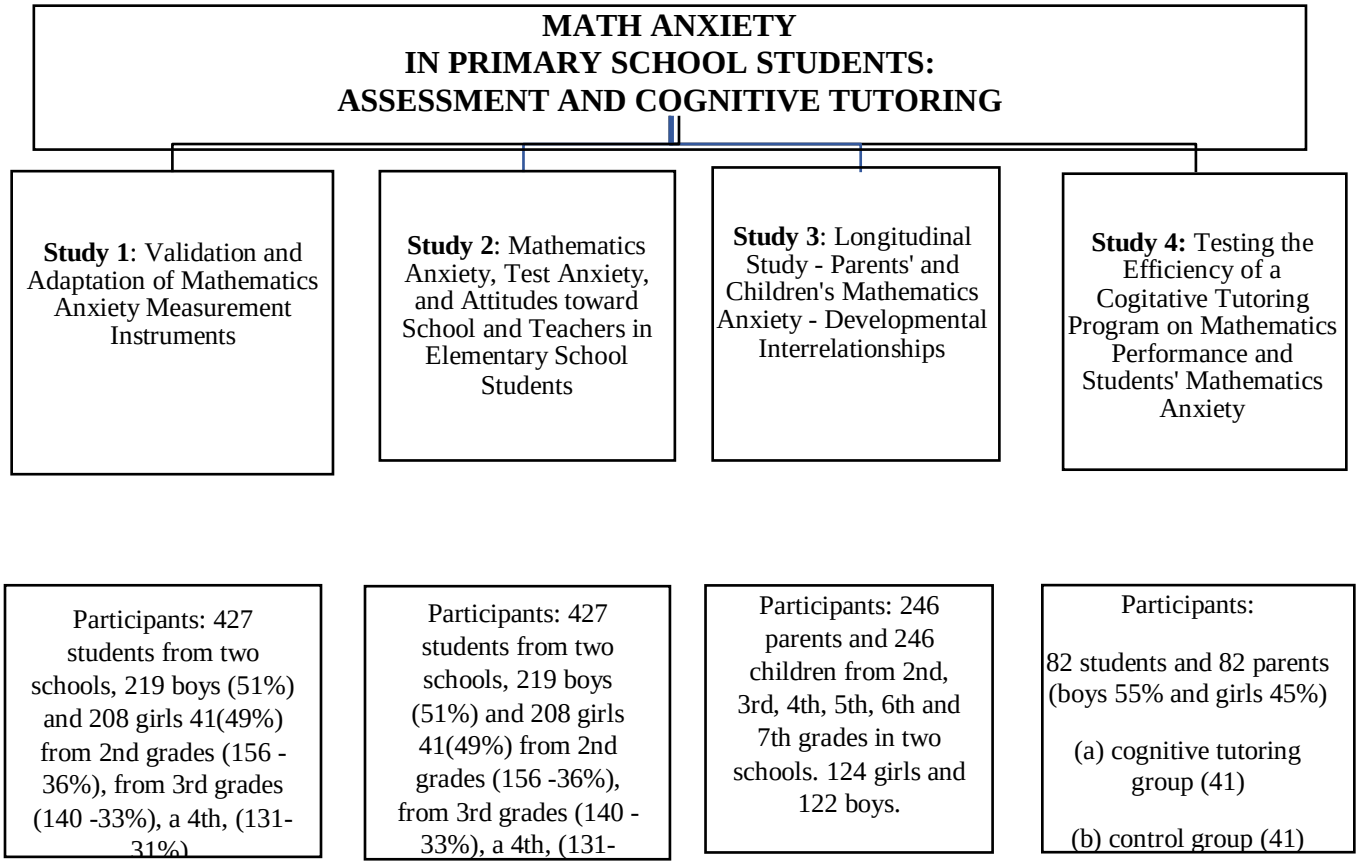


Figure 2. Structure of the current thesis (General Methodology)

* **Early Assessment of Mathematics Anxiety Scale** (SEMA: Wu, Barth, Amin, Malcarne, & Menon, 2012)

* **Modified Math Anxiety Assessment Scale**: (mAMAS; Carey, Devine, & Szűcs, 2017)

***Test anxiety** (CTAS, Douglas & Jeri 2004)

* **Scale for Early Assessment of Mathematics Anxiety** (SEMA: Wu, Barth, Amin, Malcarne, & Menon, 2012)

*** Modified Math Anxiety Assessment Scale:** (mAMAS; Carey, Devine, & Szűcs, 2017)

***Test anxiety** (CTAS, Douglas & Jeri 2004)

*** Trait Anxiety Inventory** (STAI, Spielberger, 1972)

*** Attitudes towards school and teacher** (BASC; Reynolds & Kamphaus, 1992);

***** The student's results in mathematics, the averages given by the teacher at the end of the school semester.

***Short version of the Parent Math Anxiety Rating Scale** (MARS; Suinn & Winston, 2003).

***Demographic file -** includes a series of identification data, education, occupation, income and health status of the child, etc.

*** Parental involvement in homework**Parental involvements survey (Maloney et al. 2015).

* Math tests

*mAMAS, SEMA, STAY

*Questionnaire for the Evaluation of the Mathematics application

*MARCH

*Cognitive Tutoring Program

CHAPTER III. ORIGINAL RESEARCH CONTRIBUTIONS

Study 1. Validation and Adaptation of Mathematics Anxiety Measurement Instruments

3.1.1. Introduction[3]

Mathematical skills make it possible for students to progress both academically and professionally (Ashcraft, 2002; Ashcraft and Moore,2006; Dower, 2016). However, a significant percentage of students report anxiety and emotional distress when it comes to mathematics (Ashcraft and Kirk, 2001). Statistical estimates, show us that 20% of the population experience symptoms of anxiety when solving mathematical tasks (Hembree, 1990; Ashcraft and Kirk, 2001; Ashcraft, 2002; Ashcraft and Moore,2006; Dowker, 2016) and as children progress through their educational journey, levels of math anxiety increase (e.g. Hembree, 1990).

These reactions in relation to mathematical stimuli are known in the specialized literature as math anxiety. Until now, as we have specified before, there are many studies that have investigated math anxiety among adolescent and adult populations (e.g.. Ashely and Ridley, 2005), but the number of studies that have addressed mathematics anxiety among primary and secondary school populations is much smaller. Also, many of the results obtained among pupils are inconsistent (Jackson and Leffingwell, 1999). Given these aspects, in the present study we will have the main aim of validating and adapting the instruments for measuring math anxiety in children.

3.1.2. Method

Study objectives:

The current study is a methodological adaptation of two math anxiety scales and aims to investigate the validity and fidelity of the two scales on the Romanian population - the modified

[3] The content of this sub-chapter is part of the manuscript entitled: Self-reported Mathematics Anxiety: Conceptual and psychometric considerations, published by Petruț, A., & Visu-Petra, L., in (2020), in the journal: Journal of Psychology, 66 (3), 259- 279.

math anxiety assessment scale (mAMAS) and the scale for the early assessment of math anxiety (SEMA).

Participants

The data were collected from 427 students from two primary schools in the city of Bistrița, Romania (296 of the students; 70% of the students belonging to Secondary School Number 1 and 131 of the students, representing 30% of the sample, from "Lucian Blaga" Secondary School The sample consisted of 219 boys (51%) and 208 girls 41(49%) from 2nd grades (156 students, representing 36%), from 3rd grades (140 students, representing 33%) and from the 4th grades, (131 students representing 31%).

Children's math anxiety was measured with two **instruments**:

1. The modified Abbreviated Math Anxiety Scale (mAMAS; based on AMAS; Carey, Hill, Devine, & Szűcs, 2017) The scale contains 9 items, with two subscales:

a) mathematical learning anxiety (items 1,3,5,7,9) (eg: *How calm or anxious do you feel when you have to complete a worksheet by yourself*)

b) math assessment anxiety (items 2,4,6,8) (eg: *How calm or anxious you feel when you think about a math test the day before you take it*)

The participants' task was to read each sentence and think about how anxious they would feel in each situation, and then circle the number that they thought best described the calm or anxious state in each situation involving mathematics, on a 5-point Likert scale from 1 = very quiet, 2 = quite quiet, 3 = slightly restless, 4 = quite restless, to 5 = very restless.

2. Scale for Early Math Anxiety Assessment: Scale for Early Math Anxiety (SEMA; based on MARS, Wu, Amin, Barth, Malcarne, & Menon, 2012) Cronbach's α SEMA=.87

The scale has 20 items divided into two subscales:

a. Competence (1-10): How anxious I am when I have to answer questions like:

• *15 − 7 = 8. Is that correct?*

b. Situation (11-20): how worried I am in situations like:

• *The teacher gives me some addition exercises to solve*.

The first 10 items were designed to assess anxiety related to mathematical problem-solving competence and the last 10 items were designed to assess social situation and test anxiety. On a 5-point scale indicating how anxious he/she would feel during certain situations involving mathematics. (1 = very quiet, 2 = quite quiet, 3 = slightly restless, 4 = quite restless, 5 = very restless).

3. Test anxiety - Children's test anxiety scale (CTAS; Wren and Benson, 2004 based on RCMAS; Douglas and Jeri, 2004), 30 items which included 9 items from the autonomic reaction's subscale, 8 items from the Off-Task Behaviors subscale and 13 items from the Thoughts subscale. A 4-point Likert scale was used to describe how the tests are performed. (1 = almost never, 2 = sometimes, 3 = often, 4 = almost always).

4. Demographic sheet - includes a series of identification data, the relationship with the child, education, occupation, income and health status of the child.

5. Involvement in homework - To investigate parents' involvement in homework, I used the Homework Involvement Questionnaire completed by parents; It contains 5 items that refer to the frequency with which parents get involved in doing homework (eg: *How often do you engage in the following behaviors to help your child with math homework*, eg "*I check the homework at the end, I answer the questions on who has them along the way, I remind him/explain result where I see that he is making a mistake, I help him/her to actually solve the exercise where he/she does not manage, I get involved from the beginning in doing the exercises with him/her?*"). with 7 response options on a Likert-type scale measured on a Likert scale (0=never, 6=more often than once a day).

Procedure

In a first stage, we obtained the research ethics approval from the scientific council of Babeș Bolyai University, then we identified the two schools in Bistrița Năsăud county and the classes targeted by our research. I obtained the agreement of the management and the classroom teachers; We selected all the 2nd, 3rd and 4th grades from Secondary School No. 1 and "Lucian Blaga"

Bistrița Secondary School; After receiving the school's consent, following discussions with the classroom teachers, parents' consents were distributed. Sealed envelopes with forms were sent to parents to provide their consent for their children to participate in the research. The consent forms explained the purpose of our study and provided assurances regarding confidentiality of information. Each student received a packet containing the parental consent in duplicate and the parent questionnaires. Parents were informed on WhatsApp groups or by phone about the nature of the experiment, its purpose, methods and about their right to agree or not to participate in this study with their child or to withdraw at any time; discussions regarding confidentiality of data and results.

The deadline for signing the agreements and completing the questionnaires was one week. Of the 728 participants, only 427 received parental consent. Among the parents who signed the parental agreements, 427 also completed the questionnaires for parents, which we received together with the agreements. After collecting the envelopes, a convenient time for completing the scales was established with the classroom teachers;

Later, in the second stage, at the date and time set with the class teacher, the students completed the prepared questionnaires. The students were informed about the purpose of the study and were assured that their answers would not be shared with the teachers in the classroom. We read aloud and clearly the requirements of each form to the students and asked them to answer the questions. Students were asked to complete all questionnaires patiently and in order, to allow enough time to answer all questions and to ask any additional questions if anything was unclear about the meaning of the questions.

All test instruments used in this study were translated into Romanian by a team of specialists from Babeș Bolyai University, Faculty of Psychology, RIDDLE Research Laboratory. During the evaluation, the students were constantly supervised and received additional explanations when needed. A pleasant psycho-educational climate was created, accessible language was used, short, clear, concise sentences;

Then the actual testing took place. It lasted between 20 and 50 minutes and the children's reactions at first were curiosity and restlessness. The teacher and I decided to read out the first items to clarify the content and then let the pupils complete the questionnaires individually at their

own pace. We gave most guidance on the maths quiz, we had to make it clear that we were not solving the operations, but just choosing the option that best suited them. We had to give them a range of information about what the words "sometimes" and "frequently" mean. We also reminded them that there is no right or wrong answer and that their answers should be as honest as possible. For those who completed their homework early, we handed out age-appropriate short story books to keep those who needed more time to complete the tests calm and focused.

The third stage consisted of re-applying the tests after a two-week interval in accordance with the schedule established by mutual agreement with the classroom teacher.

Mentions and difficulties in the procedure

The attitude of the teaching staff was positive, collaborative and actively involved. Students were compliant and actively involved in completing the questionnaires. Each student's own pace of work was respected. After two weeks the questionnaires were retested. This time the pupils were given surprise games, counselling and personal development. The difficulties encountered were related to the relationship with parents (postponement, delayed signing of agreements, return of forms three days later). Students who did not receive parental consent remained in the classroom with the other children and received another task (to read). Even if they did not receive a set of questionnaires, they were attentive to the explanations and interested in the completion of the questionnaires by their colleagues.

3.1.3. Results, Discussions and Conclusions

The main aim of this study was to adapt two scales of mathematics math anxiety in Romanian primary school.

Summary of main findings:

The results indicate that:

1. The Romanian versions of the math anxiety scales show satisfactory indicators of fidelity and validity.

2. The convergent and divergent validity of the mAMAS and SEMA scales provide strong evidence of their utility in measuring mathematics anxiety in children and adolescents.

3. The exploratory factor analysis (EFA) chosen by us, allowed the analysis of the data from the 131 students of the Lucian Blaga school. For the 20 items of the SEMA scale, inspection of the correlation matrix indicated that all items have at least a correlation coefficient greater than .3. The Bartlett test of sphericity was statistically significant indicating that the data were factorable.

4. Visual inspection of the scree graph indicated that the optimal solution is the one based on two factors: for SEMA the factors: Competence (1) and Situation (2) and for mAMAS the factors: Learning (1) and Evaluation (2); These results being confirmed by the study conducted by Hopko et al. (2003).

5. The two-factor solution in SEMA fitted the data best (explaining 40.20% of the total variance). The interpretation of the data can be accommodated by the structure proposed in the original instrument, the items corresponding to the competence scale loading strongly on factor 1 and the items of the situation scale loading strongly on the second factor.

6. The mAMAS two-factor solution best fitted the data (48.07% of the total variance).

7. The interpretation of the data can be accommodated by the structure proposed in the initial instrument, the items corresponding to the mathematics learning anxiety scale loading factor 2 and the items of the mathematics assessment anxiety scale loading strongly factor 1, except for item 9 ("*How anxious would you feel when starting a new math lesson*") that loads both factors (learning anxiety and assessment anxiety) perhaps due to the fact that starting to teach a new lesson involves two components of didactic design. The evaluation of the information already taught, on the structure of which the teaching and learning of the new information is carried out.

8. In the case of SEMA, the indicators suggested an adequate fit of the data to the model. substantiates the conclusion of the satisfactory fit between the data and the model discovered following the exploratory analysis, confirming the data obtained in the specialized literature (Cipora et al. 2015).

9. In the case of mAMAS, indicators suggested an adequate fit of the data to the model, similar to the fit found in the studies by Cipora et al. (2015).

10. Given the confirmation of the factorial structure of the scales, we assessed their internal consistency using the entire sample. For the competence subscale of the SEMA and for the situation subscale of the SEMA, the values of the subscales showed good internal consistency. Across the scale suggesting excellent internal consistency. For the assessment anxiety subscale of the mAMAS, indicating acceptable internal consistency and for the learning anxiety subscale

indicating good internal consistency. Like the entire scale, it suggests the presence of good internal consistency. Similar results were also obtained by Ahmad, Hussain and Khan, (2018).

11. The test-retest coefficient for both SEMA and mAMAS demonstrated acceptable reliability. The change in scores between test moments can be attributed to students' adaptation to the scales and the person who administers them, replacing the emotional factor related to the task of completing unknown scales in the presence of an unknown persona with already known scales in the presence of the person next to them carried out self-knowledge and personal development activities.

12. To test the construct validity, the average variance extracted (AVE), the Fornell-Larcker criterion and the analysis of the extent to which the items load the latent variables based on an ESEM model were used. The SEMA scale, the mAMAS scale, and the CTAS scale were included in the analysis to examine the extent to which math anxiety differs from test anxiety in general. The AVE indicators indicate deficiencies at the level of convergent validity, but the strong correlation between the SEMA and mAMAS scales and the fact that most of the items of these scales load strongly and statistically significantly both latent constructs are evidence in favor of convergent validity.

13. The divergent validity between SEMA and CTAS was confirmed by the fact that the root of AVESEMA = .60, which is higher than the correlation value between the two scores, but not between mAMAS and CTAS. For the math anxiety items of both scales, the factor loadings on the assessment anxiety factor were at least 10 lower than on the scale-specific factors, with the exception of the mAMAS math assessment anxiety items. Taken together, these aspects suggest satisfactory discriminant validity for both scales.

14. Regarding the criterion validity, the scores on the SEMA scale showed negative, statistically significant correlations with the average in mathematics, the involvement of parents in homework and the school results of parents in primary, secondary and high school classes, their performance in mathematics.

15. Scores on the mAMAS scale showed negative, statistically significant correlations with the average in mathematics, parents' involvement in homework, the history of parents' achievements in mathematics in primary classes, the history of parents' achievements in mathematics in secondary schools, the history of parents' achievements in mathematics in high school classes and parents' math performance.

Since its development, the AMAS has been translated into several languages for use with different populations. Translations of the scale into Romanian, Polish, Italian and Persian have been found to be valid and reliable (Vahedi and Farrokhi, 2011; Primi et al. 2014; Cipora et al. 2015). Although mathematics education from 2000 to the present has seen significant progress through the diversification of textbooks and auxiliary offers, nevertheless, Romanian students perform significantly below the international standard, according to PISA data. Math anxiety has been confirmed to have negative consequences on math skills, so many international studies on the measurement of math anxiety have become a relevant source of information about math performance and math anxiety and are a rich source for further investigations in different communities.

Our results for the Romanian population adaptation of math anxiety scales showed mean math anxiety scores for SEMA and MAMAS compared to other studies that used English versions of the measures (Wu et al. 2012; Carey et al. 2017). It is essential that researchers and educational psychologists have a valid and reliable measurement tool for math anxiety because extremely frequent math anxiety is associated with poor mathematics performance and avoidance of mathematics-related activities.

Having a valid, reliable, and brief math anxiety measurement tool allows researchers to easily assess math anxiety in children and work with them to overcome emotional problems. At the same time, the instruments for measuring math anxiety allow us to evaluate the progress made following cognitive tutoring programs in improving math anxiety and implicitly in increasing mathematical skills.

Our analyzes underline the fact that both translated versions of The Children Early Math Anxiety Scale (SEMA) and The Children Modified Abbreviated Math Anxiety (mAMAS) provide valid and reliable measurements of Romanian children's math anxiety in 2nd, 3rd grades and 4th in primary school, which can be used by educational researchers for the benefit of educational progress. Continued investigation and evaluation of other samples is needed to further validate and standardize the mAMAS and SEMA to readily identify math anxiety in the early stages of math skill development. Our findings highlight the need to address early math anxiety and reduce its negative effects. In the following studies, we will start further investigations on mathematics performance, attitude towards school and parents' math anxiety, and the effectiveness of tutoring programs on mathematics skills.

Study 2. Mathematics Anxiety, Trait Anxiety, Test Anxiety and Attitude towards School and Teachers in Primary School Students

3.2.1. Introduction

Math anxiety is a widespread phenomenon around the world. In the US, nearly 93% of adults report some level of math anxiety and 30% of adolescents have high math anxiety (Luttenberger et al. 2018). Math anxiety has been defined as a combination of unpleasant feelings such as stress, strain, fear, and dread in situations that require math or arithmetic skills (Wijesuriya, Tran, & Craig, 2007; Chen & Zhang, 2018). It has been intensively studied in recent years, but most studies have focused on middle school or high school students. Very few studies have investigated math anxiety in elementary school students, grades 1-4.

According to Spielberger (1973), anxiety as a trait refers to those stable interindividual differences regarding a predisposition to anxiety and which underlies the differences between children in terms of the tendency to manifest anxiety states (Murris, 2007). The increased level of anxiety usually occurs when individuals encounter stimuli in the environment that can cause feelings of worry, fear and stress, such as a test situation, assessment of skills. Confronting these assessments has unpleasant consequences for test performance. Test stress or test anxiety is synonymous with worry and negative appraisals that result in a negative physiological, behavioral, or emotional response (Zeidner, 1998; Hancock, 2001; Ahmad, Hussain, & Khan, 2018).

At the beginning of the 20th century, there were more than 1000 publications on test anxiety (Pekrun and Stephens, 2015). Many previous studies have indicated that 25-30% of students have test anxiety (Sung, Chao, & Tseng, 2016; Bhatta, Subba, & Bhandary, 2018). In fact, test anxiety occurs before, during, or after test situations and results from two reasons: when an individual perceives the situation as a personal threat and when an individual believes that their own coping strategies are ineffective (Schnell, Tibubos, Rohrmann, & Hodapp, 2013)

3.2.2. Method

Study objectives and hypotheses

1. Investigating the relationship between math anxiety, trait anxiety, and attitude toward school and teachers in primary school students.

2. Exploring gender differences in both math anxiety, test anxiety and trait anxiety.

3. Capturing the relationship between math anxiety and test anxiety and students' math scores.

I formulated the following assumptions:

(1) There are gender differences between math anxiety and test anxiety, girls have higher levels of anxiety than boys;

(2) There is a positive relationship between test anxiety and math anxiety;

(3) Children's attitudes towards school and teacher is related to math anxiety; (Children who will record a high level of math anxiety will perceive teachers' attitudes as negative).; (Children who will register a high level of math anxiety will perceive teachers' attitude as negative).

(4) Trait anxiety and test anxiety are predictors of math anxiety;

(5) Attitude towards school and teachers are predictors of math anxiety;

Participants: Data were collected from 427 students from two primary schools in the city of Bistrița, Romania (296 of the students, representing 70% of the students from the Number 1 Secondary School and 131 of the students, representing 30% from the Lucian Blaga Secondary School 219 boys (51%) and 208 girls 41(49%) from the 2nd grade 156 students (representing 36%), from the 3rd grade 140 students (representing 33%) and from the 4th grade, 131 students representing 31%).

Procedure: same as in study 1. In a first step we have obtained the research ethics opinion from the scientific board of Babes Bolyai University.

The instruments used in the data analysis of this study were:

1. Scale for Early Math Anxiety Assessment: Scale for Early Math Anxiety (SEMA; Wu, Amin, Barth, Malcarne, & Menon, 2012) - 20 items, 2 subscales

a. Competence: (eg. *How anxious are they when they have to answer questions like: 15 − 7 = 8. Is that correct*?; *George bought two pizzas, each with 6 slices. How many pizza slices did George have in total*?)

b. Situation: (eg. The teacher gives you to solve some addition exercises; You are in class and you solve a math exercise on the blackboard.)

2. The modified Abbreviated Math Anxiety Scale (mAMAS, Carey, Hill, Devine, and Szűcs, 2017) with 9 items

3. Test anxiety - Children's test anxiety scale (CTAS; Wren and Benson, 2004 based on RCMAS; Douglas and Jeri, 2004), 30 items which included 9 items from the autonomic reaction's subscale, 8 items from the Off-Task Behaviors subscale and 13 items from the Thoughts subscale. A 4-point Likert scale was used to describe how the tests are performed. (1 = almost never, 2 = sometimes, 3 = often, 4 = almost always).

4. Trait Anxiety Inventory (STAI- form C-2 (Charles D. Spielberger, 1972), trait anxiety form, consisting of 20 items that includes a series of statements that girls and boys tend to use for to describe himself on a 3-point Likert scale (1 = rarely 2 = sometimes, 3 = frequently). (eg: I worry too much, I have a hard time deciding what to do.) This was administered in 2 stages (pre and post-intervention).

5. The student's mathematics results, the averages given by the teacher at the end of the school semester, were used. For the primary classes, the following ratings were made: not good enough = 1, good enough = 2, good = 3, very good = 4 and I was among the best = 5, and for the secondary classes the grades 4, 5 and 6 = insufficiently good (1), grade 7 = good enough (2), grade 8 = good (3), grade 9 = very good (4) and grade 10 I was among the best (5).

6. Attitudes towards school and teacher: with 2 subscales from the Child Behavior Assessment System (BASC 2, Reynolds and Kamphaus, 2010):

a. attitudes towards school (8 items) (eg. I am bored at school. I am not interested in school.)

b. attitudes towards the teacher (10 items) (eg. My teacher cares about me. The teacher makes me feel stupid).

3.2.3. Results, Discussions and Conclusions

The main aim of this study was to investigate mathematics anxiety in primary school students and its relationship with test anxiety, trait anxiety, attitude towards school and attitude towards teachers.

Secondary objectives consisted of exploring gender differences in both math anxiety and test anxiety; exploring the relationship between math anxiety and test anxiety and students' math achievement.

Studies of math anxiety have focused on gender differences and teachers' attitudes in attributing math success (Fennema et al. 1990, Tiedemann 2000). There appears to be a tendency for elementary school teachers to attribute mathematical success and ability to boys, whereas attribution of mathematical success to girls is related with the ability to put forth sustained effort (Fennema et al. 1990).We expected that those children who registered a high level of math anxiety would perceive teachers' attitude as negative. We also wanted to capture the relationship between the level of math anxiety and test anxiety and students' math achievement. We expected that trait anxiety and test anxiety would predict math anxiety. We expected that attitude toward school and teacher would be a predictor of math anxiety.

The data were collected from 427 students from two primary schools in the city of Bistrita, from the 2nd grades 156 students (representing 36%), from the 3rd grades 140 students (representing 33%) and from the 4th grade -a, 131 students representing 31%).

Summary of main findings

1. There are significant differences between girls and boys in the results obtained for math anxiety at SEMA, Girls have a higher level of math anxiety (hypothesis 1). Results in agreement with those obtained by Xie, Xin, Chen and Zhang, (2019). The results we obtained led us to find differences between girls and boys on both scales of math anxiety, which is consistent with many previous studies (Schnell et al. 2013; Xie et al. 2018). A similar finding was reported by Carey et al. (2017) on increased levels of math anxiety among 4th grade girls compared to boys using the Math Anxiety Scale (mAMAS). While our results contradict those of Newstead (1998), Tapia (2004), Chiu and Henry (1990), and Birgin et al. (2010) findings that reported no differences between boys and girls.

One possible explanation for girls experiencing higher levels of math anxiety may stem from gender differences in socialization practices. In particular, girls socialize to express their

feelings and emotions, this may lead to their tendency to admit their fears when faced with anxiety (Schnell et al. 2013).

Our scores showed that girls performed slightly better in mathematics than boys, this result refuted the results of studies suggesting that boys outperform girls in mathematics (Rapp, 2015; Osborne, 2006) and refutes the assumption that mathematics is a male domain (Tomasetto, 1947).

Our results are consistent with the results of many recent studies that have shown the narrowing of the math achievement gap between boys and girls over the years (Hyde et al. 2008; Gunderson, 2012) and similar math achievement scores for both genders where girls choose to pursue math courses or careers related to math skills (Eccles, 2009).

2. Positive, statistically significant correlation was found between assessment/test anxiety (CTAS) and math anxiety (on both SEMA and mAMAS scales) (hypothesis 2), results that were also confirmed by the studies carried out by Thomas, Cassady and Finch, (2017); Xie et al (2018).

As in our study, Hembree's (1990) meta-analysis confirmed that girls report higher levels of anxiety than boys. In general, women tend to report higher levels of anxiety than men (Sung, Chao, & Tseng, 2016; Szafranski, Barrera, & Norton, 2012). A possible explanation for this phenomenon is that women are more likely to perceive the assessment or test as threatening rather than a challenging situation, which maintains their state of test anxiety (Bruno, 2015).

Another potential reason may relate to the fact that women overestimate the stimuli compared to men, which can be seen as a result of reporting higher levels of test anxiety, despite the fact that both boys and girls are subjected to the same situation examination and experience the same test anxiety (Sung, Chaon, & Tseng, 2016).

In fact, in our education system, primary students are frequently exposed to formal examination sessions where teachers have to assess performance using many strategies such as teamwork, class responses, homework and assessment tests .

Scores on the Mathematics Anxiety Scale (SEMA) showed positive, statistically significant correlations with attitude towards school and attitude towards the teacher.

Trait anxiety was also found to differ significantly by gender, according to the current finding, girls reported higher levels of trait anxiety than boys, this finding is consistent with the findings of the study by Macher et al. (2011), who reported higher levels of trait anxiety than boys. Additionally, many studies indicate that women tend to report higher anxiety scores than men (Putwain & Daly, 2014).

These results are in agreement with our results which also showed a high correlation between the two math anxiety scales used in this study, the Abbreviated Math Anxiety Scale for Children and the Early Math Anxiety Scale for Children, this consistency between the instruments used confirmed that both scales are valid to measure math anxiety among primary school students. In Ma's (1990) meta-analysis of 26 studies, Dew, Galassi, and Galassi (1984) found a strong correlation between math anxiety scales.

3. Scores on the mathematics anxiety scale (mAMAS) showed negative, statistically significant correlations with attitude towards school and attitude towards the teacher (hypothesis 3). In this sense, Beilock et al. (2010) pointed out the tendency of teachers who show a high level of mathematics anxiety in transferring students' anxiety during teaching, in the classroom, especially influencing the results of girls, by expressing the gender stereotype and the belief according to for which mathematics is a specifically male field.

4. The trait anxiety predictor (STAI) contributed statistically significantly to the model, explaining 41% of the variance of math anxiety, and the test/assessment anxiety predictor contributed significantly to the model, explaining 40% of math anxiety (mAMAS). (hypothesis 4) results confirmed by other studies (Meece, Wigfield, & Eccles, 1990; Von der Embse, Jester, Roy, & Post, 2018). Teacher attitude explaining a significant proportion of math anxiety. In a similar study investigating predictors of math anxiety in a sample of 7th-9th grade students, the results were similar to predictors of math anxiety (Meece, Wigfield, & Eccles, 1990). Trait anxiety has been shown to be the strongest predictor of math anxiety (Macher et al. 2011). Many studies have attempted to investigate the relationship between mathematics anxiety and mathematics achievement, and several studies have shown that mathematics anxiety is a predictor of mathematics performance (Ma, 1999; Miller & Bichsel, 2004; Ayotola & Adedeji, 2009).

5. The attitude towards the teacher predicted, math anxiety explaining 13% of math anxiety (mAMAS).

The attitude towards school predictor explained in a proportion of .08% the math anxiety (mAMAS) (hypothesis 4). The data we obtained are in agreement with those obtained in specialized literature (Carey, Hill, Devine and Szucs, 2017).

Therefore, within the prevention programs in schools, the need to organize cognitive tutoring sessions to reduce students' anxiety is fully justified. We believe that programs that meet the needs

of teachers and support them in optimizing their teaching activity, with an emphasis on the student and less on the content, to gain efficiency in classroom interaction, would be of real benefit.
Previous reviews suggest that the concept of test anxiety is often difficult to separate from math anxiety, so the relationship between math anxiety and test anxiety was investigated. Math anxiety has been positively correlated with test anxiety and general anxiety (Thomas, Cassady, & Finch, 2017; Xie et al. 2018).

In this respect, our findings revealed a positive correlation between math anxiety and test anxiety. Given that math anxiety has been viewed as a form of test anxiety, most math anxiety questionnaires consist of some items on math test situations, and it was expected that the two would be correlated (Dew et al. 1984). .

Furthermore, our results showed a strong and positive correlation between trait anxiety and other measures of anxiety (SEMA, mAMAS, and CTAS). Similar findings were revealed by Ashcraft and Moore (2009), who reported a significant and positive correlation between math anxiety and trait and test anxiety (McDonald, 2001; Wigfield and Eccles, 1988). In fact, math anxiety has been conceptualized as a situation-specific (i.e., trait) anxiety demonstrated in math-related activities (Rubinsten, Eidlin, Wohl, & Akibli, 2015), whereas test anxiety has been viewed as a personality trait situation-specific, especially occurring in evaluative situations (Dew, Galassi, & Galassi, 1983; Zeidner, 2007; Schnell, Tibubos, Rohrmann, & Hodapp, 2013).

In line with these suggestions, it makes sense to find correlations between the forms of anxiety as reported in our results. In this regard, Hembree's (1990) meta-analysis reported that math anxiety correlates with math performance scores.

In fact, in the present results, we can see that the negative correlation between math anxiety and math scores is higher than the correlation between test anxiety and math scores, these results are related to the above mentioned interpretation of the educational system for elementary school students as it is based on qualitative assessment rather than examination.Highly anxious students will fall behind their peers, receive negative feedback from parents and teachers, and thus be more likely to develop negative attitudes toward school and teachers and be less motivated toward mathematics (Ashcraft and Moore , 2006; Tempel & Neumann, 2014), in light of these suggestions we also found negative correlations between children's attitudes toward school and teachers and math anxiety.

Based on previously reported findings (Bhatta, Subba, & Bhandary, 2018), we conclude that math anxiety and test anxiety levels differ in girls and boys, as girls reported higher levels of anxiety. On the other hand, both forms of anxiety are positively correlated with test anxiety, trait anxiety, math performance and school attitude, and negatively with teacher attitude. Trait anxiety and test anxiety are both predictors of math anxiety. In accordance with the study conducted by Meece, Wigfield and Eccles, (1990) and Yazici, (2017). Attitude towards school and teacher significantly explaining math anxiety.

Limitations could investigate as future research the teacher anxiety and how this variable may influence students' attitude and anxiety in the classroom. We consider it a real benefit to test the effectiveness of an intervention program for teachers on their attitude towards students.

Study 3. Longitudinal Study - Anxiety of Parents and Children

3.3.1. Introduction

Numbers are an essential part of our lives and daily activities (in cooking, shopping, managing money and reading the clock). Numeracy skills assessed at an early age predict crucial life factors such as academic success, employment opportunities, salary size, socioeconomic status, personal and social well-being (Pellizzoni, Cargnelutti, Cuder, Passolunghi, 2021). Considering the importance of numerical skills, it is crucial to elucidate the factors that can promote or hinder the process involved in learning this school subject. The specialized literature has extensively investigated the general cognitive skills required but also the emotional factors that seem to have a rather large influence on math performance. Math anxiety has been the subject of extensive study over the past 60 years. Aware of the importance of cognitive and other factors for success in mathematics, researchers are now focusing on identifying factors that can predict mathematics achievement (Fonteyne, Duyck and De Fruyt, 2017) and on the influence of the interaction of these factors on learning (Passolunghi, Cargnelutti and Pellizzoni, 2019).

That said, only a few contributions to date have focused on how emotional factors mutually affect mathematics proficiency, particularly in elementary school students (Cargnelutti, Tomasetto, & Passolunghi, 2017). This study is thus one of the first attempts to conduct a

longitudinal study on the interaction between one of the most robust relevant emotional precursors (math anxiety and test anxiety) and to examine their specific contribution on mathematics results in the Romanian population, respectively on primary and secondary school students. The aim is to extend the knowledge gained from previous studies.

Ma and Xu (2004) found the bidirectional relationship between math anxiety and math acquisition. Thus, the presence of a high level of math anxiety at the beginning of schooling predicts poor mathematical acquisitions at the end of the primary grades, and poor mathematical acquisitions at the beginning of schooling predict the presence of math anxiety in the following years of the primary cycle. The relationship between math anxiety, math performance (eg numeracy skills, applied math, geometric reasoning) and working memory was assessed longitudinally using autoregression analyses. The results showed that math anxiety led to a decrease in math performance, but only for students with higher visual-spatial memory capacity. The results obtained in this study also support the role of working memory in the relationship between math anxiety and math performance (Ashcraft and Kirk, 2001; Vukovic et al. 2013; Ramirez et al. 2013).

Another study that assessed the relationship between math anxiety, math performance, and working memory was conducted in 2017 by Ching. In this study, 246 children in China were followed from 1st grade to 2nd grade. The authors investigated whether levels of math anxiety measured in 1st grade would predict numeracy and narrative problem-solving skills one year later, and whether there was an interactive effect between math anxiety and working memory that have an impact on children's performance (Ching, 2017). In this regard, two hypotheses were formulated:

(1) Mathematics anxiety will have a negative contribution on mathematical performance in difficult tasks, independently of the children's cognitive abilities, and

(2) Students with an increased working memory capacity will have a greater likelihood of performance as a consequence of math anxiety. In other words, math anxiety will correlate negatively with the performance of students who have higher working memory capacity (Ching, 2017).

As predicted in the first hypothesis, the results showed that math anxiety correlated negatively with math performance, in terms of calculation skills and narrative problem solving. Furthermore, this link was not explained by general anxiety, test anxiety, or non-verbal skills (eg,

intelligence, working memory, or numerical skills). Also, math anxiety had an impact on math performance, but not on reading performance. These results are important because they show that children's math performance is a unique longitudinal predictor of children's math performance. However, these results were nuanced. The results showed that math anxiety did not affect all children equally. According to the second hypothesis, only children who had a higher working memory capacity (Ching, 2017).

At school, the prevalence of math anxiety is in the range of 2–17% (Caviola, Toffalini, Giofrè, 2021) depending on the student population considered and the criteria used to define the condition. A crucial question in the debate about the emergence of math anxiety concerns whether it is a cause or a consequence of math difficulties. 77% of the time, children with severe math anxiety perform at or above typical math (Devine, Hill, Carey, & Szucs, 2018), suggesting that cognitive and emotional problems related to math are largely dissociated. However, the mechanisms underlying this relationship between cognitive and emotional factors shaping children's mathematics achievement remain to be elucidated.

From our point of view, a multilevel analysis, to delineate the specificity of math anxiety and the extent to which it is associated with math performance, would be extremely necessary. Last but not least, the development of a panel study, a longitudinal study, in which data are collected from the same set of students (sample or panel) at certain points in time, through repeated measurements, helps to better understand math anxiety, of how this affects math performance across development, leading to a better understanding of the causal link between math achievement and math anxiety and how interventions can be designed to be beneficial in the long term.

Given the conflicting findings on this topic, our research aims to shed light on the relationship between math anxiety and math efficiency in primary and secondary grades. Our first aim will be to check whether math anxiety can, in particular, affect math performance even in young children and whether there is a possible reciprocal influence. I collected data from students in 2nd, 3rd, and 4th grades and then returned to the students at an interval of 3 years when they were in 5th, 6th grades and 7th, attempting to define both competing and developmental patterns in relation to math anxiety. Worrying is the finding of the authors Cargnelutti, Tomasetto and Passolunghi, (2017) who, following a longitudinal study on 2nd and 3rd grade students, found that the effect of math anxiety can increase over time (Thomas and Dowker, 2000), possibly due to the accumulation of negative experience in relation to the mathematics discipline.

3.3.2. Method

The main purpose of this study was to investigate the relationship between mathematics anxiety and test anxiety among elementary and middle school students. Also, to explore gender and class differences in both math anxiety and test anxiety. We also set out to investigate the relationship between math anxiety, parents' involvement in homework and students' results in mathematics.

To capture the three-year (2019-2021/2022) evolution of math anxiety in children and parents through a repeated measures study.

Based on the literature analysis, we issued the following hypotheses:

1) 1) Middle school students tend to report higher levels of math anxiety and test anxiety than elementary students tend to report higher levels of math anxiety and test anxiety than middle school students.

2) There is a positive association between math anxiety test scores and test anxiety in elementary and middle school students.

3) Math anxiety and test anxiety will be negatively associated with math achievement.

4) Also, parents' higher level of math anxiety is positively associated with child's math anxiety as a result of child-parent interaction.

5) There is a positive association between parents' math anxiety and children's math performance.

6) Parental math anxiety predicts children's math performance.

7) Parental involvement in homework predicts math performance.

Participants:

Parents: The participants in this study were 246 parents of which 33 fathers and 169 mothers and the remaining 44 were completed by mother and father together. The majority of parents had a good average income, with 53% of parents earning above average and 47% earning average and below average per capita. 77% of mothers; 65% of fathers had higher education, while, 23% of mothers and 35% of fathers had vocational education. Parents in our study were the ones who agreed to participate with their child in our research.

The sample of children consisted of 246 students from the 2nd, 3rd, 4th, 5th, 6th and 7th grades from two primary schools in the city of Bistrița. 124 girls and 122 boys of which 34% alone with parents, 44% with a brother or sister, 16% with 2 siblings and 6% with three or more siblings. 101 participants were in the 2nd grade, 94 participants were in the 3rd grade and 51 were in the

4th grade, who participated in a 3-year interval (in the 5th grades, the 6th and 7th) to the study based on repeated measurements. The selection of the student sample was based on parental consent to participate in our study with their children.

Instruments:

Children's math anxiety was measured with two instruments:

1. The modified Abbreviated Math Anxiety Scale (mAMAS; based on AMAS; Carey, Hill, Devine, & Szűcs, 2017) The scale contains 9 items, with two subscales:

a) mathematical learning anxiety (items 1,3,6,7,9) (eg: How calm or restless do you feel when you have to complete a worksheet by yourself)

b) math assessment anxiety (items 2,4,5,8) (eg: How calm or restless do you feel when you think about a math test the day before you take it)

Participants read each sentence and think about how anxious they would feel in each situation, then circle the number they think best describes how calm or anxious they feel in each situation on a 5-point Likert scale points to indicate how anxious they would feel in certain situations involving mathematics (1 = very calm, 2 = quite calm, 3 = slightly anxious, 4 = quite restless, 5 = very restless.

2. Test anxiety - Children's test anxiety scale (CTAS; Wren and Benson, 2004 based on RCMAS; Douglas and Jeri, 2004), 30 items which included 9 items from the reactions subscale autonomous, 8 items from the Off-Task behaviors subscale and 13 items from the thoughts subscale. A 4-point Likert scale was used to describe how the tests are performed. (1 = almost never, 2 = sometimes, 3 = often, 4 = almost always)

3. The student's results in mathematics were used, the averages given by the teacher at the end of the school semester. For the primary classes, the following ratings were made: not good enough =1, good enough =2, good =3, very good = 4 and I was among the best =5, and for the secondary classes the grades 4, 5 and 6 = insufficiently good (1), grade 7 = good enough (2), grade 8 = good (3), grade 9 = very good (4) and grade 10 I was among the best (5).

In the case of parents, they were administered:

4. The short version of the Mathematics Anxiety Rating Scale (MARS; Richardson and Suinn, 1972, based on the original 98-item MARS scale; Suinn and Winston, 2003) (Wu, Amin , Barth, Malcarne, & Menon, 2012) that contains 30 items that has a reliability coefficient of .95, and an internal consistency of .97. With two subscales:

a) Part A – situations from the student period involving mathematics (includes items 1-15)

(Example: How stressed did you feel when you were a student "When you knew there was a math test the next day"? "When you knew there was a math test in a week"; "When get a math thesis") and

b) Part B - refers to hypothetical situations from the present that involve numerical processing (includes items 15-30)

(eg: How stressed do you feel when: "You get a set of multiplication problems to solve" "You have to add 976+777 on paper"," You have to calculate the annual budget", "You have to check a receipt fiscal").

Parents must report the level of stress felt in each situation presented on a 5-point Likert scale (1=not at all stressed, 2=a little stressed, 3=not much, not a little, 4= quite stressed, 5=very stressed.

5. Demographic sheet - includes a series of identification data, the relationship with the child, education, occupation, income and health of the child.

6. Involvement in homework - To investigate parents' involvement in homework, we used the Questionnaire for homework involvement completed by parents; It contains 5 items that refer to the frequency with which parents get involved in doing homework (eg: How often do you engage in the following behaviors to help your child with math homework, eg "I check the homework at the end, I answer the questions on who has them along the way, I remind him/explain rexuli where I see that he is making a mistake, I help him/her to actually solve the exercise where he/she does not manage, I get involved from the beginning in doing the exercises with him/her?"). with 7 response options on a Likert-type scale measured on a Likert scale (0=never, 6=more often than once a day).

Procedure

In a first phase, we obtained the ethical research approval of the Scientific Council of Babeș-Bolyai University. Then we set with the partner schools the dates and times allocated for the testing. The children were tested in two different stages. The first, Time 1 (at the beginning of 2nd, 3rd, or 4th grade) was devoted to the assessment of math anxiety (children's self-report, test anxiety, and parents' ratings of their math anxiety and involvement in homework) and students' results in mathematics based on the averages obtained at the end of the semester. Then, at Time 2 (at the beginning of 5th, 6th, or 7th grade), students' math and test anxiety and final math grades, parent math anxiety were tested again and homework engagement.

The procedure was identical to that of the first study carried out in 2019. In a second stage, I returned after three years (2022) to the two schools in Bistrita Năsăud in the 5th, 6th and 7th grades - from Secondary School No. 1 and "Lucian Blaga" Bistrita Secondary School; to the 427 participants in the 2019 study requesting their voluntary re-engagement in the study based on parental consent. Among the 427 participants, 246 students and parents re-filled the questionnaires.

Mentions and difficulties in the procedure

A good compliance of the students was observed, being actively involved in completing the questionnaires. Each student's own work pace was respected. This time, after completing the questionnaires, the students were prepared for an hour of surprise games, counseling and personal development.

Students who did not receive parental consent remained in the classroom with the other children and were given another task (to read). Even though they did not receive a set of questionnaires, they participated in the group activities but did not receive rewards. Some of the students who participated in the 2019 study moved to other schools or classes. For some of them, although they would have liked to participate in the study, they did not succeed due to the fact that the parents did not fit in the time to complete the participation agreements and the questionnaires.

3.3.3. Results, Discussions and Conclusions

Given previous research showing increases in math anxiety over the school years and that middle school students tend to report higher levels of math anxiety and test anxiety than grade school students secondary schools (hypothesis 1) through this study we aimed to longitudinally investigate these constructs on a sample of primary and secondary school children.

The obtained results confirmed the data from the specialized literature. Many studies have shown that math anxiety increases with age, starting from childhood to adulthood (Rossnan, 2006; Ramirez et al. 2018).

Preliminary analyzes revealed differences in mathematics performance between elementary and middle school students. Students' scores dropped by an average of 1 point as they moved from elementary to middle school. And math anxiety also increased between elementary and middle school by 4.5. The results are in agreement with those obtained in the study by Živković, Pellizzoni, Mammarella and Passolunghi, (2022).

2. Following the theoretical arguments provided, we investigated whether there is a statistically significant relationship between the scores on math anxiety and test anxiety in the primary and secondary grades obtained by the children in our study. We obtained a positive, significant relationship between math anxiety and assessment anxiety in primary school students, respectively a moderate, positive correlation between math anxiety and assessment anxiety in secondary school students (hypothesis 2).

3. We obtained a negative, low significant relationship between math anxiety and the performance of primary school students, respectively small and negative between math anxiety and the results of secondary school students (hypothesis 3). The results being consistent with those obtained by Živković and collaborators (2022).

Also, a negative correlation could be noticed between test anxiety and the performance of primary school students, respectively negative and small between math anxiety and the results of secondary school students (hypothesis 3).

Our results are relatively close to those obtained in other studies and reached the threshold of statistical significance. We investigated whether there was a statistically significant relationship between parent and child math anxiety scores as a result of the interaction.

Thus, we obtained a positive, small correlation between parent-child math anxiety in primary grades, respectively between math anxiety of secondary school students. Recent meta-analytic investigations confirm a significant negative correlation between math anxiety and math performance (range: $-0.30 < r < -0.34$), and this link begins to take root early in an eligible child's school years by Zhang, Zhao and Kong, (2019).

The negative impact of math anxiety on math performance has been confirmed in many studies. In general, anxious individuals may perform more poorly on math tests than nonanxious individuals (Devine et al. 2012; Al Mutawah, 2015; Beilock & Maloney, 2015; Wilder, 2017).

In fact, the interaction relationship between math anxiety and performance has two possible causal directions. Cognitive interference theory, which holds that anxiety causes individuals to perform poorly in math by affecting working memory resources, and deficit theory, which holds that awareness of poor math performance leads to greater math anxiety. Although parents in our sample did not report lower levels of math achievement in elementary and middle school, they did report lower levels of math achievement in high school, in addition, 75% of our parents were

mothers, consequently their anxiety may stem from the common belief about mathematics as a male domain, which may negatively affect their mathematics performance.

4. We obtained a positive, small correlation between parents' involvement in homework and primary school children's math anxiety, respectively positive but small for secondary school students (hypothesis 4).

5. We observed that there are no statistically significant relationships between parents' math anxiety and the results of primary and secondary school students. Thus, we obtained a small positive correlation between parents' math anxiety and children's math performance in primary grades, respectively a small negative correlation between parents' math anxiety and children's math performance in secondary grades (hypothesis 5).

6. Parents' math anxiety is a predictor of the school results of primary school students in mathematics. It significantly and negatively predicts mathematics results in primary and secondary school students (hypothesis 6).

More recent studies have observed the link between math achievement and math anxiety by finding positive correlations between parents' negative thoughts and attitudes toward math and math achievement (Pugsley & Price, 2018) and have shown that parents' attitudes and beliefs play a role significantly in the early stages of the education process. Parents convey to children their own feelings about their own school experiences, often without realizing the long-term consequences (Wilder, 2015).

7. It was found that the involvement of parents in homework significantly and negatively predicts the math results of primary and secondary school students. The predictors explained a total of 17% of the variance in mathematics results (hypothesis 7). We attribute these results to the large differences in parental involvement and their lack of mathematical skills for the secondary school level.

As a general conclusion of this chapter, I have the finding that parents' math anxiety can have a negative impact on children and learning mathematics, which is why we consider it necessary to be aware of the crucial role played by parents' emotional experience towards mathematics, so that parental help with homework home to prove beneficial.

The present longitudinal study shows a combined effect of emotional and cognitive factors that stands out in the elementary and middle grades. They suggest a crucial influence of anxiety as

a variable that can consistently affect math achievement. Math anxiety has a negative impact on school performance from an early age and appears to increase over time.

The findings of this study have important implications in the educational setting. It emphasizes the essential role of the parent in the emotional evaluation of the learning process. Evidence suggests that children with math difficulties may benefit from early intervention to help them cope with anxiety. Such an intervention as rehabilitation programs that only focus on improving mathematical skills and their cognitive precursors could be ineffective if children do not learn how to manage their negative emotional states (Passolunghi, De Vita, & Pellizzoni, 2020). The home environment, parents' perceptions of mathematics have a notable impact on children's attitude, self-esteem and cognitive abilities (Parsons & Kaczala, 1982; Batchelor, Gilmore, & Inglis, 2017; Mohr-Schroeder, Ronau, Peters, Lee, & Bush, 2017), future research could focus on creating favorable environments for interaction between child-parent and mathematics.

Our proposal in this regard is to use cognitive tutoring programs in mathematics learning to support children and parents to learn and practice mathematics in an interactive, pleasant and relaxed environment by accessing digital materials. We believe that cognitive tutoring programs would favor interaction situations between children and parents by developing the parent's ability to control their negative emotional impulses in the presence of their own children and to discover mathematics as a challenge. In this sense, we propose learning mediated by a cognitive tutoring program adapted to the age and psychological characteristics of children, with exercises and problems that are well structured and easy to access.

Limits - Considering the objectives and hypotheses of the study, we specify that the limit is represented by the inter-individual differences that were visible during testing. Most of the children were tested at the same time, but the pace at which they completed the questionnaires was very different. Also, the degree of understanding of the task and the questions differed from one student to another. At the same time, we also mention the fact that in the comparison of the data with those from the specialized literature, no research was found in which the concepts were measured as in the current study.

Future research directions could investigate the connection of other emotional factors such as relaxation techniques, how they influence math anxiety. It could also be investigated and analyzed how the anxiety of the teachers can influence the anxiety of the children in the classroom.

Study 4: Testing the Effectiveness of a Cognitive Tutoring Program on Mathematics Performance and Students' Mathematics Anxiety

3.4.1. Introduction

Digital technologies are an essential aspect in developing cognitive tutoring programmes that meet the needs of new generations. In recent years, there has been a growing openness towards the integration of computers in the educational approach. Anderson (1995) cognitive tutoring can take the form of instructional technology, accessible through the computer. In other words, the human tutor can be replaced by a technologically mediated variant, in which instructions are based on a cognitive model of the skills the user aims to learn.

[4]Currently, there is a generous number of training programs that aim to evaluate mathematical skills, analyze learning methods, as well as provide educational experience based on the cognitive tutoring model. The programs are very varied in terms of the quality of the mathematical content they offer, the feedback, the interactions, but also the adaptability they show (Cayton-Hodges, Feng, & Pan, 2015; Feng, Xie, & Liu, 2017 ; Alanazi, 2020). These applications can be accessed from the phone, tablet, but also from the computer, in online or offline format. Despite the wide accessibility, the empirical validity is low, due to the fact that there is a limited number of studies to theoretically substantiate these games (Vanbecelaere, Cornillie, Sasanguie, Reynvoet, & Depaepe, 2021).

Research that has included such programs has found improved math skills as well as increased acceptance of the subject. However, few of the existing studies have focused on reducing math anxiety (Szczygiel, 2020). Another noteworthy aspect that emerges from the analysis of the studies is that online cognitive tutoring programs seem to be more attractive for both students. In addition, parents' reports also reveal the same (e.g. Chappell et al. 2015; Alanazi, 2020; Živković, Pellizzoni, Mammarella and Passolunghi 2022).

[4] The content of subchapter 3.4.1. is part of the manuscript: Computerized math tutoring programs designed to reduce math anxiety and improve math performance in primary and secondary school children., published by Petruț, A., & Visu-Petra, L., in 2020 in Revista de Psihologie, 13(25), 7-31.

Taking into account all these results, the cognitive tutoring program we validate is similar to the mathematical cognitive tutoring program developed by Supekar and colleagues in 2015 (Supekar et al. 2015). In developing this program we also took into account the critical analysis by Sokolowski and Necka (2016) of the study by Supekar and colleagues in 2015.

The rationale behind the study is similar to the rationale in the literature that the most effective techniques in reducing anxiety in both children and adults is exposure (e.g. Van Etten and Taylor, 1998; Wolitzky-Taylor et al. et al. 2008). The assumption behind exposure is that prolonged and repeated exposure to anxiogenic stimuli leads to a decrease in anxiety levels (Abramowitz et al. 2011). Thus, like Supekar et al. (2015), we believe that a cognitive tutoring program that aims to improve math skills has the potential to reduce math anxiety through exposure.The second rationale comes from studies showing negative associations between elevated levels of math anxiety and academic achievement (Richardson & Suinn, 1972; Viehe & Segal, 1982; Resnick, Wigfield, & Meece, 1988; Hembree, 1990 ; Ma, 1999; Byun and Joung, 2018).

We will describe the development and piloting of the cognitive tutoring program for reducing math anxiety. "Mathematicians". This program is aimed at primary school children (2nd and 3rd grades) and is based on the Romanian education curriculum.[5]

Regarding the content of the Computerized Mathematical Tutoring Program, Matematrolii program (Visu-Petra et al. 2019) was developed in the Laboratory of Developmental Psychology and RiddleLab of the Babeș-Bolyai University by a team coordinated by the supervisor of this doctoral thesis (www.minimanx.ro), being developed with the help of a specialist in mathematics teaching (Conf. Ioana Magdaș), the involvement of primary school teachers and with the help of IT specialists, in order to be appropriate for the age and level of schooling of the students, according to the curriculum from Romania .

This program was delivered via a web platform. To ensure adherence and optimal performance of the tutoring program, they were assisted by a teacher. Regarding the delivery format of the program, it was delivered in a group format. More specifically, we divided the

[5] The content of subchapter 3.4.1. is part of the manuscript: The effectiveness of cognitive tutoring programs in reducing math anxiety, published by Cacuci, S., Magdaș, I., Costan, A., Petruț, A., & Visu-Petra, L. in 2022, in M. Cruz, A. Couto, & F. Lambert (Eds.), IssuEs'22- Issues in Education (pp. 29-49). Politécnico do Porto, Escola Superior de Educação, Portugal.

students into groups of minimum 9 - maximum 19 students. To foster student engagement in the program, the platform uses a space theme: children are encouraged to "explore the math galaxy" to discover eight planets one after the other.

For 4 weeks, they attended 1 session each week, playing on one planet at a time, for a total of 4 sessions. Each session lasted between 45 and 60 minutes and contained both simple exercises such as addition and subtraction, multiplication and division for 2nd graders and more complex exercises with fractions and finding unknown terms for 1st graders 3rd.

The 49 students in the experimental group were divided into 4 groups of minimum 8 students, maximum 19 students. Each student worked from a separate computer, obtaining a user address and password.

If kids solved all the exercises on a planet, they could land and play a mini-game. They could collect gems from the planet that could later be used to customize their avatar and spaceship, and they could also fight Mathematicians, which would clear the planet and allow them to move on to the next one. Throughout the game, kids could collect different badges for each planet and monitor their progress from the main profile.

MATEMATROL is a cognitive training program for math anxiety [6](Visu-Petra et al. 2019). The "Math Trolls" game (Image 1) starts from the known data in the specialized literature regarding math anxiety and effective strategies from already existing cognitive training programs. During 4 weeks of 1 weekly session, the children explored different planets, each of them aiming to develop specific mathematical skills. The planets have thematic names (Addendus, Diminus, Multiplis, Fracta) and combine the components of a computer game with the part of cognitive tutoring with the aim of reducing math anxiety (Image 2). It is intended to present mathematics in a way that is less aversive or potentially distressing. The story of the game follows a linear path, with the hero being called to save the universe by the "mathematrol" robots. On his way, the hero explores the galaxy and completes various space missions, all with the help of mathematics.

[6] Part of the content of this sub-chapter 3.4.1. is part of the manuscript: Computerized math tutoring programs designed to reduce math anxiety and improve math performance in primary and secondary school children., published by Petruț, A., & Visu-Petra, L., in 2020 in Romanian Journal of School

Image 1. Home page of the "Mathematicians" game”[7]

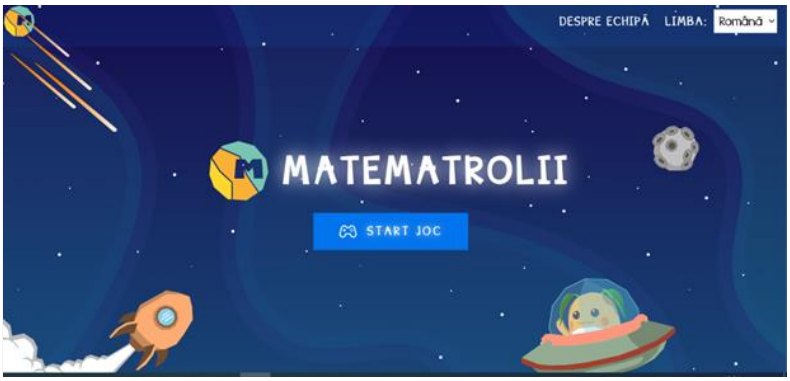
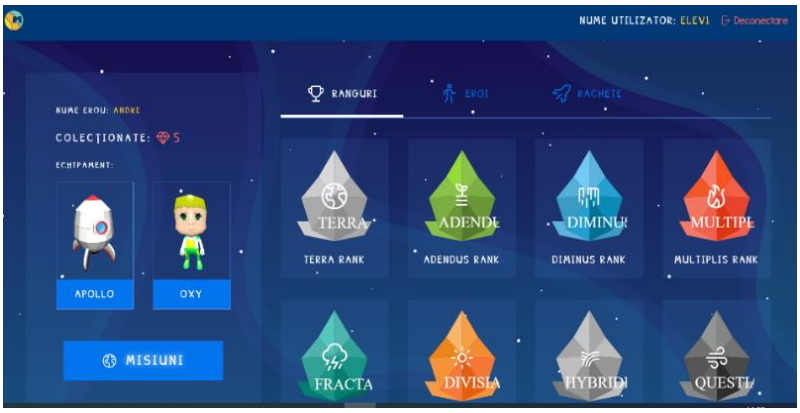


Image 2. The frame in the game



The tutoring element is revealed by the way children can request the help of a virtual tutor, who will point-by-point show them the steps to solve problems. The request can be explicit, on demand, but also automatic, when the child gives a wrong answer. The visual explanation is duplicated by the audio one, but they are not interdependent. You can opt for the full version (audio + visual presentation), or just the visual one. The tutor's explanations are similar to those offered by the teachers during the course hours, so that the children are already familiar with this way of presenting information.

Another advantage of this game is the possibility of configuring the exercise packages according to the content you want to learn or practice. Given the content of the program for the

[7] The content of this sub-chapter is part of the manuscript presented at the symposium. "Matematrolii"- a software program for technology-assisted intervention in reducing math anxiety. APR Conference, "Psychology and Technology: Connect to the Future", supported by Cacuci, S-A., Cheie, L., Buta, M., Magdaș, I., Costan, A., Petruț, A., Visu-Petra, L. in 2021 11-14 November, Bucharest, Romania

2nd grade, only certain levels can be solved by children in this educational cycle. However, the wide variety of exercises allows making special packages, where children practice addition, subtraction, learn about fractions or the order of operations. Given that the exercises gradually increase in difficulty, even children who are not yet used to a certain type of exercise can solve them with the help of individualized feedback (Image 3).

Images 3. Planets - Missions

The cognitive training program, The Math Game, was created to be applied online, both within the experimental studies in this project and as a tool to reduce math anxiety. Data collection is based on mathematics anxiety questionnaires translated and adapted by us (Scale for Early Mathematics Anxiety, SEMA, Wu et al. 2012 and The modified Abbreviated Math Anxiety Scale, mAMAS; Carey et al. 2017) which we administered them to assess the level of math anxiety. Thus we identified a sample of school-age children recruited for the comparative study, some of which show a high level of math anxiety. The sample comprises two distinct groups, one group receiving training with the Mathematrol game to improve mathematical skills, and another group receiving no game training as part of the control group. Data collection was done to be able to compare the results of the two working groups.

3.4.2. Method

Study objectives

The main goal of the intervention is to help children with math anxiety to practice and develop their problem-solving skills using a gamification component (Vanbecelaere, Cornillie, & Depaepe, 2021). In this sense, we expect that between the students in the cognitive tutoring group and the

control group, there will be differences from the perspective of the results in the mathematical training test applied post-intervention. The secondary aim of this study is to validate and investigate the effectiveness of the computer tutoring program in the two groups in developing math skills and reducing math anxiety.

Assumptions

(1) The group that benefited from cognitive tutoring will have a better performance than the control group regarding the results obtained in the math test.

(2) There is a negative association between Mathematrolii accuracy test scores and math anxiety in the cognitive tutoring group.

(3) There is a positive association between accuracy of answers on Mathematrolls and math anxiety in the cognitive tutoring group.

(4) There is a positive association between parental math anxiety and student math achievement.

(5) The computerized math tutoring program will be associated with a positive attitude of students towards mathematics.

Participant

The participants are 82 students (of which 45 boys representing 55% and 37 girls representing 45%) from the "Lucian Blaga" Secondary School in Bistrița-Năsăud County, Romania, based on a collaboration agreement with the school (see Annexes). Criterion the selection of the participants was based on the informed consent of the parents. The indicators of the socio-economic status of the participants (family income, maternal education, paternal education) followed a normal distribution: 49% of families have an average net income, 55% of mothers they have a high school diploma, and 55% of the fathers have a high school diploma, 99% are of Romanian ethnicity, 100% have Romanian nationality and 96% have children in good health.

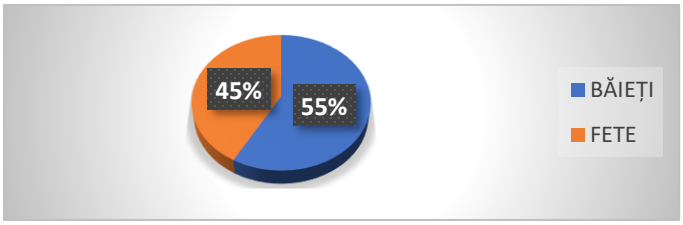


Figure 7. Participants (N=82)

Before starting the cognitive tutoring on Mathematrolii, all children completed a series of questionnaires to assess the level of math anxiety and anxiety as a trait and a test of knowledge called "mathematical test" to check the level of development of mathematical knowledge. Subsequently, the children were randomly assigned to either (a) the cognitive tutoring group to which the computerized math tutoring program (Mathematrolii) was delivered, consisting of 16, 2nd grade students, and 25, 3rd grade students (total 41 students) (b) either they were part of the control group, being put on a waiting list and explaining to them that they would be able to access the platform and the math games after completing the cognitive training by peers from neighboring classes. This group consisted of 16, 2nd grade students and 25, 3rd grade students (41 students in total).

The computerized math tutoring program was delivered between 13.05.2022 and 30.05.2022. And the re-application of the math tests and the re-application of the questionnaires was done in the first week of June 2022 in all four classes in the experimental and control groups. 31% of the participating students were from the 3rd house, and 19% students from the 2nd class - a. Regarding the distribution of students by class, this can be found in the Table below:

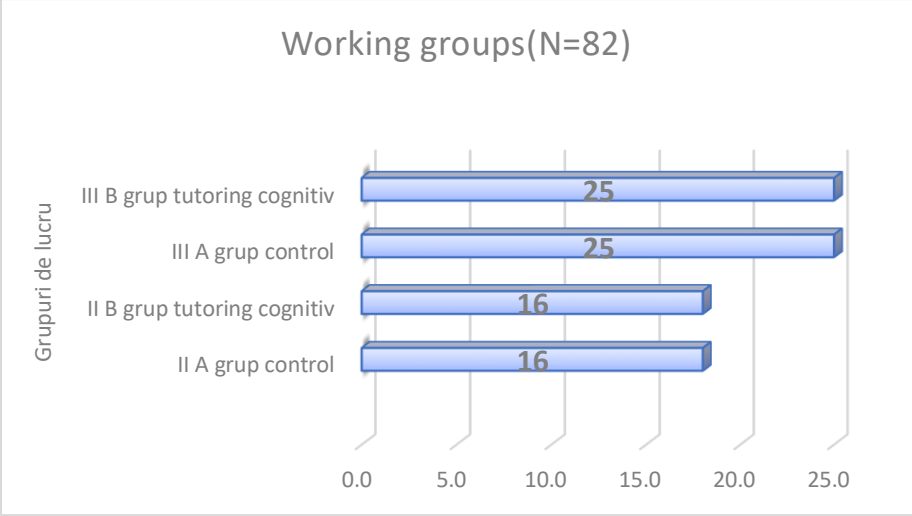


Figure 8. The composition of student groups by class

As can be seen from the graph above, the cognitive tutoring group to which the Mathematicians training program was delivered consists of 16, 2nd grade students and 25, 3rd

grade students (total 41 students) and the control group consisted of 16, 2nd grade students and 25, 3rd grade students (total 41 students).

From one stage to another of the experiment, the number of students in the experimental and control groups remained intact. 99% of the students of the two classes participated in the study, with one abstention each. Students with special educational needs were excluded from the study in order to have as similar groups as possible and to eliminate intra-group differences.

Measuring instruments

1. For the measurement of mathematical skills, we would use the results obtained by the students in the mathematics tests distributed before and after the intervention to both the experimental and control groups for the assessment of mathematical skills. To select the exercises and problems, the Matematrolii platform and the students' textbooks were used.

The items of the math test were discussed and analyzed together with the classroom teachers, respecting the school curriculum. The working time was set at 40 minutes for solving the test items in both the 2nd and 3rd grade (exercises and problems of addition, subtraction, multiplication, division for the 2nd grade and for the 3rd to those mentioned, fractions were added, and exercises to find the unknown term).

The test includes 3 exercises and one problem each for the operations of addition, subtraction, multiplication and division for the 2nd grade, and for the 3rd grade, the test contains three exercises each for the operations of addition, subtraction, multiplication and division and in addition to the 2nd grade, and three operations with fractions and 3 with finding the unknown term. The testing was administered face-to-face, in the classroom. Each student worked individually, at his own pace. For each item solved correctly, the students received 3 points. The scores were calculated for each type of operations separately, so for addition operations the maximum score was 12 points - in the 2nd grade (4 items x 3 points/item) and in the 3rd grade, the maximum score it was 9 points (3 items x 3 points/item). At the end of the intervention, the students gave a new similar test, made according to the same principles and operations. The purpose of the test was to evaluate the performance in mathematics, after the intervention stage with the mathematical cognitive tutoring program in both the experimental and control groups.

2. To measure Math Anxiety we used two instruments, in 2 stages (pre and post-intervention): a) The modified Abbreviated Math Anxiety Scale (mAMAS; based on AMAS; Carey Carey) , Hill, Devine, & Szűcs, 2017) with 9 items and two subscales: math learning anxiety

(items 1,3,5,7,9) (eg: *How calm you feel when you have to complete a worksheet alone?) and math assessment anxiety* (items 2,4,6,8) (eg: *How calm or anxious do you feel when thinking about a math test the day before you give it*?)

Participants read each sentence and think about how anxious they would feel in each situation, then circle the number they think best describes how calm or anxious they feel in each situation on a 5-point Likert scale points to indicate how anxious they would feel in certain situations involving mathematics (1 = very calm, 2 = quite calm, 3 = slightly anxious, 4 = quite restless, 5 = very restless.

b) To measure children's math anxiety, we also used the Scale for Early Math Anxiety (SEMA; Wu, Amin, Barth, Malcarne and Menon, 2012). The scale has 20 items divided into two subscales:

a. Competence (1-10): *How worried they are when they have to answer questions like:*

• *15 − 7 = 8. Is that correct*?

b. Situation (11-20): *How calm they are in situations like:*

• *The teacher gives you to solve some addition exercises*.

3. Trait Anxiety Inventory (STAI- form C-2 (Charles D. Spielberger, 1972), trait anxiety form, consisting of 20 items that includes a series of statements that girls and boys tend to use for to describe himself on a 3-point Likert scale (1 = rarely 2 = sometimes, 3 = frequently). (eg: I worry too much, I have a hard time deciding what to do). This was administered in 2 stages (pre and post-intervention).

4. Questionnaire for the Evaluation of the Matematrolii application - with 10 items - students' opinion about the application (Bilgin et al. 2021). It includes open-ended items to a series of questions related to student feedback on enjoyment, usefulness, problems encountered, recommendations, the contribution of the application to lessons and mathematical skills, the help that the application provides in exams and tests, the suitability of age and whether the exercises, problems and game in the app were challenging for the students.

In the case of the parents, they were administered

5. The short version of the Mathematics Anxiety Rating Scale (MARS; Richardson and Suinn, 1972, based on the original 98-item MARS scale; Suinn and Winston, 2003) (Wu, Amin , Barth, Malcarne, & Menon, 2012) that contains 30 items that has a reliability coefficient of .95, and an internal consistency of .97. With two subscales:

a) Part A – situations from the student period involving mathematics (includes items 1-15)

(Example: How stressed did you feel when you were a student "When you knew there was a math test the next day"? "When you knew there was a math test in a week"; "When you were going to get a math thesis") and

b) Part B - refers to hypothetical situations from the present that involve numerical processing (includes items 15-30)

(eg: How stressed do you feel when: "You get a set of multiplication problems to solve" "You have to add 976+777 on paper"," You have to calculate the annual budget", "You have to check a receipt fiscal").

Parents must report the level of stress felt in each situation presented on a 5-point Likert scale (1=not at all stressed, 2=a little stressed, 3=not much, not a little, 4= quite stressed, 5=very stressed.

6. Demographic sheet - includes a series of identification data, the relationship with the child, education, occupation, income and health status of the child.

Procedure

Before conducting the study, I have requested the Agreement for the Research Ethics Approval, from the scientific council of Babeș-Bolyai University. After the Ethical Visa was granted, we contacted the principals of the "Lucan Blaga" Secondary School, from Bistrița-Năsăud county in Romania, in order to set up a meeting. This meeting had the role of familiarizing the school staff with the purpose of the study and its stages. With the consent of the school principals, we selected two 2nd and 3rd classes each. The female teachers were contacted and informed about the study. We contacted the parents and distributed the participation agreement and parent questionnaires (homework engagement, math anxiety questionnaire, and demographic sheet) for completion. We informed the parents on the classes' WhatsApp groups about the nature of the experiment, its purpose, methods, but also about their right to agree or disagree with the child's participation in this study or to withdraw from this study at any time; data privacy discussions, comps and results.

I have provided a phone number for parents in case of concerns. The time allotted for completion was one week. After collecting the consents I have organized a first meeting with the students to administer a set of questionnaires (measuring math anxiety and trait anxiety), explained how it worked and gave additional explanations to know what they had to do; accessible language

was used, short, clear, concise sentences; a simulation/exercise was done to demonstrate how it works (circling the option that matches their condition);

Then it was on to the actual testing. This lasted between 35 and 55 minutes and the children's reactions at the beginning were curiosity and anxiety. I decided with the teacher to let them work at their own pace without reading new items. I asked the students to raise their hand whenever something was unclear to them to clarify the content. They each worked individually, at their own pace. Despite the fact that at first they found the testing difficult, at the end they stated that it was interesting and that they would like to participate in such activities again.

We gave them the most directions on the math quiz, we had to specify that we do not solve the operations, but just choose the option that fits best. We had to give them a range of information about what the words 'sometimes', 'occasionally', 'frequently' mean. I also reminded them that there is no right or wrong answer and that their answers should be as honest and unreserved as possible.

Later in another meeting, we administered the math training tests (tests made to assess math skills). We made sure that the students wanted to participate in the testing and tried to create an appropriate psychoeducational climate.

Some exercises could be solved by both 2nd and 3rd grade students because they include simpler calculations, and others have specific contents intended exclusively for older children. The general idea of the game is that the child-user becomes the hero of the galaxy, having to solve math problems to fight against the little robot invaders (Mathematrols).

Six of the seven planets are composed of seven levels each: 6 levels include only

exercises, and level 7 is exclusively for math problems. A single planet, Divisia (which deals with division), contains 6 levels. To be adapted to each grade, the last level is structured and also contains problems for the 2nd and 3rd grades, respectively.

Each level has 3 sets of 6 exercises; the main one and two additional sets. The first set has the "go ahead" version, while the last two appear when the child gives at least 3 wrong answers to the first exercises in the previous set. For each exercise the children are asked to choose the correct answer from the 4 displayed options. The guidance element is included in how children can ask for help from a virtual tutor who will show them the steps needed to solve the problem. The first part of the feedback occurs automatically when the child gives a wrong answer. They can then look at pictures that show them how to solve the first part of the exercise, while a voice prompt repeats the feedback.

The tutor's explanations are similar to those given by the teachers during the lessons, so the children are already familiar with how the information is structured. Another relevant feature of the game is the possibility to configure the exercise according to the content to be learned or practiced. The wide variety of exercises makes it possible to create personalized packages where children can practice addition or subtraction, but you can also learn about fractions or the order of operations. As the exercises gradually increase in difficulty, even children who are still unfamiliar with a particular type of exercise can progress using instant feedback for guidance.

The seven planets have thematic names: Addendus for learning addition, Diminus for subtraction, Multiplis for multiplication, Divisia for division, Fracta for learning fractions, Questia for solving complex exercises and Hybridia for practicing combined sets[8]. The program lasted 4 weeks and consisted of 4 sessions of increasing difficulty. Each session lasted between 45 and 60 minutes and contained both simple and complex exercises.

Mentions and difficulties in the procedure

The teaching staff showed a positive, collaborative attitude and got actively involved. A good compliance of the students was noted, being actively involved in completing the questionnaires, solving the math tests as well as in the tutoring and math training program. Each student's own work pace was respected.

The difficulties encountered were related to the relationship with parents (postponement, late signing of participation agreements, late return of forms). Parents in the 3rd grade control group expressed disappointment that their children were not selected for the intervention. By requesting additional information when signing the agreement, they expected their children to benefit from the activities within the Matematrolii platform.

Learning that they were put on a waiting list, they mobilized and asked the teacher for an extra hour of mathematics per week. After completing the intervention, the control group was allocated an hour in the ICT laboratory and each received access codes to the Matematrolii platform.

The students were very attracted by the rewards they received after completing each stage, completing questionnaires, testing their math skills, and math tutoring. The rewards consisted of

[8] Part of the content of chapter 3.4.2. is part of the manuscript entitled: The effectiveness of cognitive tutoring programs in reducing math anxiety, published by Cacuci, S., Magdaș, I., Costan, A., Petruț, A., & Visu-Petra, L. in 2022, in M. Cruz, A. Couto, & F. Lambert (Eds.), IssuEs'22- Issues in Education (pp. 29-49). Politécnico do Porto, Escola Superior de

school supplies (eg: ergonomic pens, neon notebooks, pencils, erasers, rulers, colored pencils, markers, sticky notes, etc.).

3.4.3. Results, Directions and Conclusions

1. The cognitive tutoring group performed worse than the control group on the math test.

As for the experimental group, the overall average of the pretest results was 7.12 and the overall average of the post-intervention results was 7.24. So the results of the experimental group increased by 0.12 points. The low increase in the results obtained by the experimental group from one stage to another of the intervention can be attributed to demotivation and the lack of seriousness with which they completed the final math training test. The students seemed to be more motivated by the desire to finish the test as quickly as possible and receive the final reward. Unlike those in the experimental group, those in the control group were very motivated and attentive to completing the final test associating the result obtained with the probability of being selected to play in the ICT laboratory and practice mathematics in a fun way.

The causes of low math achievement among elementary and secondary students have been studied extensively in recent years (e.g., Eden, Heine, & Jacobs 2013; Ramirez, Gunderson, & Susan, Levine, & Beilock, 2013). Results of studies that investigated the variables behind this phenomenon indicate that one of the most important factors that greatly influence the process of learning and acquiring mathematical skills is math anxiety (e.g. Ashcraft, 2002; Geary, Hoard, Byrd- Craven, & De Soto, 2004; Swanson, 2006; Ashcraft, 2009).

2. A negative association was observed between Mathematrol accuracy test scores and math anxiety in the cognitive tutoring group.

Meta-analyses that synthesized the results of studies that investigated the relationship between math anxiety and math performance among primary and secondary school students show us that there is a negative association between the level of math anxiety and math performance (Hembree, 1990; Ma, 1999). Subsequent experimental studies have also highlighted the link between math anxiety and deficits in various mathematical calculation and problem-solving skills among students (Richardson & Suinn, 1972; Viehe & Sexal, 1982; Resnick, Wigfield, & Meece, 1988; Hembree, 1990; Ma, 1999; Vukovic et al. 2009).Thus, addressing math deficits becomes a necessary component in a program that attempts to reduce math anxiety.

3. The results show us the presence of an insignificant, negative relationship between the accuracy of the answers in the platform and the results on the anxiety scales towards mathematics ($r = -.21$, $p > .05$) at SEMA respectively ($r = -.-18$, $p > .05$).

The results indicated the presence of a significant positive relationship between the results on the two scales measuring math anxiety ($r = .84$, $p < .01$). Increased accuracy of math answers is positively related to decreased math anxiety.

4. There is a negative association between parental math anxiety and student math achievement.

It can be seen that there were no positive, statistically significant relationships between the parents' math anxiety and the results of the math training tests in the two working groups. Negative associations were found between the results of the two work groups both in the pretest and in the post-intervention stage.

In order to verify the hypothesis (5) according to which the computerized math tutoring program will have a positive impact on the students' attitude towards mathematics, we will resort to the qualitative analysis of the answers given by the students to the application evaluation items by the 2nd grade students and the 3rd.

The qualitative analysis of the answers provided by the students to the App evaluation items by the 2nd and 3rd grade students highlighted the pleasure felt by the students when working in the application. All respondents found it useful arguing with various reasons such as the fact that it helps them with calculations or helps them think. A small part of the students encountered problems like 1+1 operation when the internet connection was weak. All students would recommend the app to friends because it was challenging, easy, enjoyable, engaging and they felt they learned by playing.

At the end of the activity, the students left the ICT room with enthusiasm, eager to participate in a new activity as soon as possible and curious to explore new planets. The atmosphere during the game was one of enthusiasm, joy, curiosity and active involvement in all the activities carried out. Some students played from home even at 10 pm or even at 0 am, declaring that "the game got to them". Later they were warned about the appropriate times for calculations, problems and mathematical games. Many students wanted to resume the programmed planet and the 7 levels for the planets Adensus, Diminul, Multiplis, respectively 6 levels for the planet Divisia to play the final reward game again.

Moreover, another line of studies that is the basis of the foundation of the present program indicates that one of the most effective techniques in terms of reducing anxiety, both in the case of children, is exposure (Van Etten and Taylor, 1998; Wolitzky-Taylor et al. 2008): prolonged and repeated exposure to anxiety-provoking stimuli leads to a decrease in anxiety levels (Abramowitz et al. 2011). Therefore, our tutoring program involving the math stimulus work component has the potential to reduce students' math anxiety through exposure.

The tutoring program implemented in the two classes is similar to the math tutoring program developed by Supekar and colleagues in 2015 (Supekar et al. 2015). In developing this program also started from the weaknesses (e.g. weaknesses, sampling method, interpretation of results and unexplored mechanisms) of the study of Superkar and collaborators pointed out by Sokolowski and Necka (2016): in terms of sampling issues, unlike Supekar et al., we chose to randomly assign participants to the two groups, and in terms of unexplored mechanisms, we chose to test math anxiety as a mechanism of change in the relationship between our tutoring program and performance on math tests. mathematical training.

Our computerized math tutoring program was delivered to 2nd and 3rd graders via a web platform. Unfortunately, cognitive training did not lead to an increase in math performance in math training tests, but it did not have a good effect in reducing math anxiety. These results are consistent with studies that have highlighted the close relationship between math anxiety and deficits in mathematical calculation and problem solving skills among students (Richardson & Suinn, 1972; Viehe, & Sexal, 1982; Resnick, Wigfield and Meece, 1988; Hembree, 1990; Ma, 1999; Vukovic et al. 2009) and with the results obtained by Supekar et al. after testing their intervention program aimed at reducing math anxiety (Supekar et al. 2015).

The tutoring program led to a reduction in students' test anxiety. This result would be consistent with the results of previous studies showing that exposure is one of the most effective techniques in reducing different types of anxiety, for different types of populations, including children (Van Etten and Taylor, 1998; Wolitzky -Taylor et al 2008). The assumption behind exposure is that prolonged and repeated exposure to anxiogenic stimuli leads to a decrease in anxiety levels (Abramowitz et al. 2011).

Limits: The short period of the cognitive training, the existence of technical and personnel malfunctions in the application of the training. Creating groups of up to 5 participants to be

followed more closely. A better division of workgroups according to the level of math anxiety (high, medium or low).

Regarding new research directions, we propose that the development of new tutoring programs should include components such as relaxation. Beyond improving math skills, we believe that relaxation is a technique that has the potential to reduce anxiety that occurs in relation to anxiogenic math stimuli (eg, Lamontagne, Mason, & Hepworth, 1985).

The effectiveness of relaxation is documented in the literature and among pediatric populations, with studies showing it to be an effective technique in reducing anxiety that occurs in relation to a multitude of subjects, such as dental visits, chronic pain and illness, or even to prolonged and severe stressors such as exposure to war (Johnson Day and Sadek, 1982). Similarly, another line of research shows that relaxation is effective in reducing student-reported stress levels and promoting alternative functional responses (eg Cowen, 1988). Based on these results, we believe that adding the relaxation component would increase the effectiveness of a tutoring program.

CHAPTER IV. CONCLUSIONS AND GENERAL DISCUSSIONS

4.1. Theoretical Considerations

The present thesis succeeded in extending the existing literature related to mathematics anxiety in several directions.

1. A comprehensive theoretical review of the scales that measure math anxiety in children and adolescents was carried out.

2. Made a theoretical review and a classification of the currently existing mathematical cognitive tutoring programs, with special interest given to cognitive tutoring programs in the computerized version.

3. Through this paper, I have contributed to the theoretical and curricular foundation of a mathematical cognitive tutoring program for 2nd and 3rd grade students.

4.2. Methodological/Practical Considerations

Providing concrete results, a reference in the school field through data and practical arguments that confirm the destructive effects of math anxiety on the school success of students in mathematics.

1. Development of computerized cognitive tutoring interventions that can be completed in class or at home with parents.

2. The adaptation of two instruments for measuring math anxiety;

3. Identifying the causes that can be the basis of math anxiety in children;

4. Investigating related constructs such as trait anxiety, test anxiety, math achievement, gender differences, and math achievement.

5. Investigating the relationship between parent and child math anxiety (Patall, Cooper, & Robinson, 2008) and factors such as homework involvement in explaining math anxiety.

6. Development with a team of specialists of a pilot cognitive tutoring program aimed at reducing math anxiety and increasing math performance in children with high levels of math anxiety.

7. Implementation of a 4-week, 2-meetings-per-week pilot cognitive tutoring program designed to reduce math anxiety and increase math achievement in 2nd and 3rd grade students.

8. The use of a longitudinal design helped us to outline a complex picture of the interrelationships between the early development of math anxiety and other constructs.

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