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DEVELOPMENT AND PILOT TESTING OF AN INTERVENTION PROGRAM FOR TEACHING GEOMETRY WITH EMOTIONAL SUPPORT

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Abstract: Mathematics is a fundamental academic discipline that underlies many real-life intellectual skills and abilities. Despite its importance, many students experience difficulties, especially anxiety and low self-efficacy, which hinder their achievement and involvement in mathematics. This study aims to develop an intervention program that addresses emotional challenges in mathematics, especially in learning geometry, for 5^{th}-6^{th} grade students. This intervention program was tested in a 6^{th} grade classroom in a pilot experiment for evaluating its effect and finding eventual aspects to be adjusted for an intervention on a larger scale. The results show that the intervention program has a significant effect on reducing mathematics anxiety and increasing achievement in geometry. Based on the observation of the researcher some adjustments to the program are made, which are presented in the paper.

Keywords: *Math Anxiety, Self-Efficacy, Teaching Geometry, Mathematics Achievement, Intervention Program.*

1. Introduction

Mathematics is the basis of academic success and plays a central role in problem solving, critical thinking, and everyday decision making (Ayuso et al., 2021; Falco & Summers, 2021). Despite its importance, students often perceive mathematics as a difficult and anxiety-provoking subject (Khasawneh et al., 2021; Levpušček, 2014). This negative perception may lead to increased anxiety about mathematics and reduced self-efficacy, creating obstacles to involvement and performance (Barroso et al., 2021; Pellizzoni et al., 2022). Math anxiety not only limits student engagement in math-related tasks but has also been linked to lower achievement on assessments (Hembree, 1990), affecting both calculation speed and accuracy (Ashcraft & Moore, 2009; Wu et al., 2012). For countries like Israel, where assessments have shown consistent underperformance in areas such as geometry, especially among younger students (Ben Harus & Davidovich, 2021), intervention is critical. Providing tools to deal with these emotional barriers can ultimately improve their personal and mathematical ability. In this paper, an intervention program for teaching geometry is presented, which emphasizes emotional support for students while learning mathematics. Geometry was specifically chosen for this intervention because it represents a critical area of mathematics that often poses unique challenges for students. Unlike arithmetic or algebra, geometry requires a combination of spatial reasoning, abstract thinking, and the ability to visualize and manipulate shapes and relationships in two and three dimensions (Juandi et al., 2022). The main aims of the intervention program are to reduce anxiety and increase self-efficacy and, in this way contribute to better achievement in geometry. Using strategies such as real-life applications, stress management techniques, and personal growth activities, the program aims to create a balanced approach to learning that supports both emotional resilience and academic proficiency. Emotional aspects are rarely addressed in mathematics classes due to time constraints or insufficient trainings for the mathematics teachers in this area. Also, teachers' confidence in teaching applications of mathematics is low (Asli & Zsoldos-Marchis, 2021). Thus, this program is innovative and useful giving concrete tools for mathematics teachers. Intervention programs that provide teachers with detailed lesson plans contribute significantly to their

professional development and enhance their confidence in teaching (Asli & Zsoldos-Marchis, 2023b). Also, the paper presents the preliminary testing of this program in a 6th grade classroom for evaluating its effect and finding eventual aspects to be adjusted for an intervention on a larger scale. The pilot study was essential to ensure that the intervention program effectively targets mathematics anxiety and self-efficacy in a structured and meaningful way. The pilot phase made it possible to refine the intervention tools, which were designed to improve mathematical skills, reduce test anxiety, and foster self-efficacy. Conducting a pilot provided valuable insights into how well an intervention would work in a real-world setting and allowed for adjustments to maximize its effectiveness in a larger-scale study.

2. The development of the intervention program and its theoretical framework

This study introduces an innovative intervention program including emotional tools to enhance students' learning experience in mathematics, especially geometry, by situating it within real-life contexts. Grounded in principles of Realistic Mathematics Education (RME), the program enables students to interact with mathematical concepts through practical, everyday scenarios, enhancing their engagement and understanding (Freudenthal, 1971). RME's approach, which aligns mathematical learning with students' real-world experience, aims to make abstract concepts more accessible, leading to a deeper connection between academic content and students' daily lives (Juandi et al., 2022; Listiawati et al., 2023). Also, a previous experiment conducted in Israel among high-school students have shown the positive effect of teaching applications of mathematics on students' attitude towards mathematics and their mathematical achievement (Asli & Zsoldos-Marchis, 2023a). The program also incorporates strategies such as experiential learning, reflective writing, and positive psychology to strengthen students' emotional resilience and self-efficacy, recognizing that mathematics learning often triggers anxiety and stress. To address the emotional challenges associated with math learning, the program integrates mindfulness exercises, positive feedback, and reflective documentation. These methods provide students with tools to manage stress and approach math tasks with a positive and balanced mindset (Ergaz, 2018; Kressley & Heath, 2020). Reflective writing encourages students to evaluate their learning process and emotional state, fostering self-awareness and promoting academic growth (Flavell, 1979; Kolb, 1984). Incorporating the emotional dimensions into teaching geometry creates a learning environment that nurtures personal development and improves students' resilience. By combining RME with emotional support strategies, this intervention addresses the whole learner, aiming to boost not only math achievement but also confidence and positive attitudes toward mathematics (Carr et al., 2021; Laakso et al., 2022). The program included 15 lessons designed to improve students' understanding of geometry while providing emotional support. Here are some activities from the intervention program: To address math anxiety, students practiced 15 different breathing exercises, inspired by mindfulness theory, to foster emotional balance and adaptability to different situations. Emotional support was further strengthened through constructive feedback given at the end of each lesson, recognizing students' efforts, and reinforcing their learning. To build self-efficacy, students engaged in replacing negative self-talk with empowering statements, cultivating positive thinking. Reflective writing exercises encouraged emotional awareness, allowing students to track their progress and synthesize their learning. Realistic and experiential learning activities connected geometry to students' daily lives through tasks such as creating models and integrating geometry with art, sports, poetry, and interactive games, which enriched their learning experience and deepened their conceptual understanding.

3. Methodology

The study was conducted in 2023.

3.1 Research Aims and Questions

The research aimed to test the effect of the intervention program for teaching geometry with emotional support on students' mathematics anxiety, self-efficacy, and achievement in geometry. Also, the activities of the program were tested by the researcher to see the eventual aspect to be adjusted in the final version of the intervention program. The research is meant to answer the following questions:

1. What is the effect of the intervention program on students' mathematics anxiety?
2. What is the effect of the intervention program on students' mathematics test anxiety?
3. What is the effect of the intervention program on students' self-efficacy?
4. What is the effect of the intervention program on students' achievement in geometry?
5. What are those activities that should be changed for a future intervention?

3.2 Participants

The participants were 21 sixth grade (11-12 years old) female students from "Shaphir" elementary school in Israel. In this school there are separate classes for male and female students, and for the pilot only one class was selected in which the researcher is the teacher.

3.3 Research instrument

The quantitative tools included structured tests/scales to measure geometry achievement, math anxiety, and self-efficacy.

- **Geometry achievement test**. Standardized tests developed by Rama[1] from the Israeli Ministry of Education were conducted for academic achievement. To reduce the risk of students remembering previous answers, two versions of the test were created with different numerical values and varying question sequences. This ensured that post-test improvements accurately reflected learning gains.

- **Self-efficacy scale**. To assess self-efficacy the students completed a self-efficacy scale validated by Schwarzer & Jerusalem (2014).

- **Mathematics anxiety scale**. To measure math anxiety, we used the Abbreviated Math Anxiety Scale (AMAS), developed by Hopko et al. (2003) for geometry-specific math anxiety. Since the AMAS did not have a Hebrew version, a "back translation" method was used to ensure accuracy, translating from English to Hebrew and back (attached in the appendices). In addition to the math anxiety scale, test anxiety and trait anxiety were also assessed. Using Spielberger's (1970) State and Trait Anxiety Inventory (STAI), this supplement was designed to examine whether students had trait anxiety, which is characterized by stable anxiety that this intervention program would not improve, or test anxiety that is present in every academic test. Demographic data on factors such as location and family size were also collected. The qualitative component was based on semi-structured interviews that allowed for an in-depth exploration of the student's experience and perceived impact of the intervention, including the interview questions in the appendix.

3.4 Research procedure

The pilot study followed the following main steps:

Baseline and follow-up assessments: To measure the effects of the program, students participated in pre- and post-intervention assessments, which included geometry and calculation tests from the Israeli Ministry of Education's standardized assessments. In addition, validated questionnaires were given to measure levels of geometric anxiety, test anxiety, general self-efficacy, and geometry-specific self-efficacy. These evaluations helped to establish benchmarks for evaluating changes during the program.

Implementation of the intervention: The core of the pilot study involved the implementation of the geometry-focused intervention program, which was designed with activities to develop personal support and academic skills.

[1] Rama-The National Authority for Educational Measurement and Evaluation, a professional state authority operating in the Israeli Ministry of Education, conducts tests and surveys administered in elementary and middle schools in Israel. The tests and surveys are available in English, language education, and also in mathematics (geometry and arithmetic). The purpose of the tests and surveys is to provide school administrators with objective pedagogical information about their schools, which can be used to develop work programs, improve teaching methods, and improve the general climate in the school.

Quantitative and qualitative data analysis performed after the pilot helped to gauge the initial impact of the pilot program on students' academic performance and emotional responses to mathematics.
The intervention plan was changed accordingly. This quantitative analysis helped identify the intervention's strengths and areas for improvement, prior to conducting the main study.
This pilot study offered vital feedback on the effectiveness of the intervention and will inform refinements to optimize the program's impact in the subsequent main study.

3.5 Data Analysis

The data collected in the study were analyzed using descriptive and inferential statistics, with t-tests and Pearson's correlation coefficients employed to explore associations and differences between variables. Pre- and post-test scores in geometry and calculation tests were evaluated, as were pre- and post-intervention questionnaires on self-efficacy (both general and math-specific) and anxiety (test anxiety, geometry anxiety, and trait anxiety). The reliability of the questionnaires was verified using Cronbach's alpha coefficient to ensure internal consistency. To validate the anxiety questionnaires, Pearson correlations were calculated among the different anxiety measures (test, geometry, and trait anxiety), and mutual correlations between anxiety measures and the self-efficacy scale were examined, confirming the instruments' validity for assessing student anxiety levels in relation to self-efficacy. Qualitative data from student interviews were thematically analyzed to identify key insights into the strengths of the intervention and areas for improvement.

4. Results

We will present the results based on the research questions. The first three research questions are based on quantitative analysis across several dependent variables.

4.1. Effect of the Intervention Program on Geometry-Math Anxiety

Table 1 contains means and standard deviations for the pre- and posttest scores on the Geometry-Math Anxiety. The t-test revealed a significant decrease in anxiety post-intervention: $t(21) = 2.35$, $p < .05$

Table 1. *Comparison of pre- and posttest results on Geometry-Math Anxiety*

Time	Standard deviation	Average	t	p
Pretest	1.09	2.95	t(21) = 2.35	p< .05
Posttest	1.05	2.39		

4.2. Effect of the Intervention Program on Situational Anxiety (Test Anxiety)

Table 2 contains means and standard deviations for the pre- and posttest scores on Test Anxiety. The t-test revealed a significant reduction in Test anxiety post-intervention: $t(15) = 2.10$, $p < .05$

Table 2. *Comparison of the pre- and posttest results on Situational Anxiety (Test Anxiety)*

Time	Standard deviation	Average	t	p
Pretest	.33	3.20	t(15) = 2.10	p< .05
Posttest	.99	2.60		

4.3. Effect of the Intervention Program on General self-efficacy and self-efficacy in Geometry

Table 3 contains means and standard deviations for the pre- and posttest scores on general self-efficacy and Self-efficacy in geometry (these two are considered together in the statistical analysis). The t-test revealed no significant (NS) difference: $t(15) = 0.23$, $p > .05$

Table 3. *Comparison of pre- and posttest results on general self-efficacy and Self-efficacy in geometry*

Time	Standard deviation	Average	t	p
Pretest	0.99	3.36	t(15) = 0.23	P > .05
Posttest	0.87	3.31		

4.4. Effect of the Intervention Program on Achievement in Geometry

Table 4 contains means and standard deviations for the pre- and posttest scores on the geometry test. The t-test revealed a significant increase in students achievement in geometry: t(21) = 5.10, p = .001).

Table 4. *Comparison of pre- and posttest results on the Achievement in Geometry*

Time	Standard deviation	Average	t	p
Pretest	23.75	45.75	t(21) = 5.10	.001
Posttest	22.23	68.18		

These findings indicate a significant improvement in the reduction of both geometry anxiety and test anxiety (state anxiety), following the intervention. While self-efficacy did not show significant changes. However, a significant improvement was revealed in geometry test scores and therefore, during the study, references were recorded to unique activities aimed at increasing self-efficacy. These findings indicated the need to review the activities and add a focus to activities designed to improve self-efficacy, especially in a larger group of students, based on the results of the pilot.

4.5. Students' opinion about the intervention program

The qualitative research, conducted after the quantitative research phase of the pilot program, explored the experience, perceptions, and feelings of sixth grade students involved in the geometry intervention. Through in-depth interviews, the students reflected on the impact of the program on their academic performance, self-efficacy, and attitude towards themselves and their geometry. The results of this qualitative research contributed essentially to find the answers to research question 5. The interviews, conducted by the researcher, were in a semi-structured format that included 15 questions focusing on changes in self-perception (attached in the appendices). The qualitative research followed a thematic approach to analyzing student responses, identifying recurring themes, and organizing them into relevant categories. This process began with a holistic reading of all interviews, identifying key words and common ideas, followed by detailed coding to generate specific themes. Key themes that emerged included the impact of the program on academic performance, improving self-efficacy, and math anxiety. Students reported improved understanding of geometry concepts, better application of principles, and more effective stress management through breathing exercises. Increased self-efficacy and goal-setting abilities also emerged, as students shared their ability to set and achieve educational goals. Attitudes toward mathematics changed positively, as students expressed a new enjoyment of geometry, especially through interactive and experiential learning. The elements of the program, such as breathing exercises and games, were highlighted as significant for improving the learning experience. Students noted the calming effect of breathing exercises, which helped them stay focused during tests and challenging situations. Games and creative activities added a layer of engagement and enjoyment, as students appreciated the structured lessons and individual assignments provided. The pilot findings suggested a need for adjustments in the main study's intervention plan, focusing activities to maximize self-efficacy and engagement. This foundation guided the main research, with the pilot providing vital insights into effective strategies that fostered positive changes in students' academic, personal, and emotional abilities.

Table 5. *Themes that emerged from the thematic analysis process*

Themes	Subthemes
Impact on Academic Performance	▪ Improvement in understanding concepts ▪ Application of principles and tools ▪ Using breathing exercises
Self-Efficacy and Setting Goals	▪ Increasing confidence in handling tasks ▪ Defining learning goals ▪ Positive change towards challenges
Attitude to Mathematics	▪ Increasing enjoyment and involvement ▪ Interactive and experiential learning ▪ Positive change in perception
Program Components	▪ Effectiveness of breathing exercises ▪ Enjoying games and creative activities ▪ Preference for structured lessons

5. Changes to The Program Following the Pilot

Following the pilot study, significant updates were made to improve the intervention program. Based on extensive feedback from the two mathematics teachers during the main study training, who were exposed to the intervention program content, from students, and the researcher's documentation during the pilot study. The program now includes more targeted activities to increase self-efficacy and academic performance. While the pilot revealed a decrease in test anxiety and improvements in academic performance, changes in self-efficacy were still not substantial. This was attributed to the limited sample size or the time needed to internalize self-efficacy tools. As a result, the main research places a stronger emphasis on carefully structured activities aimed at fostering self-efficacy. In addition, adjustments were made to accommodate diverse student needs, including variations in breathing exercises, diversity in writing assignments, and the inclusion of detailed geometric worksheets to support engagement and understanding.

Additional adjustments included renaming lessons to focus on geometric concepts rather than emotional values and creating a clearer connection between lesson objectives and content. Aesthetic improvements to the lesson materials, with the help of CANVA. Presentations screened in each lesson included in the last slide tasks and equipment required for the next lesson for both the students and the teacher.

An updated format of the lesson presentation that included embedded multimedia links to learning games, video breathing exercises, and timed tasks. To improve self-efficacy, teacher feedback, and self-evaluation at the end of each lesson were added to the task sheets.

6. Discussion and Conclusions

The pilot study was a crucial step in ensuring the clarity, accuracy, and effectiveness of the intervention program to improve geometry skills among the 5^{th} and 6^{th} graders. It also confirmed that addressing emotional factors, alongside academic ones, is essential to overcoming barriers to success in mathematics. The premise of the study was that students often view mathematical challenges as not worth the effort unless they anticipate tangible success, a view supported by research indicating that students weigh the effort against the perceived benefits of mathematics (Choe et al., 2019). By integrating tools for development and emotional support, the program will help students see mathematics as more accessible and rewarding, thus fostering a more positive approach to learning.

The pilot study showed that the intervention was effective in reducing situational and geometric context anxiety. However, self-efficacy did not show significant improvement, highlighting the need for specific activities aimed at self-confidence and resilience in mathematics tasks. The results confirm the overall approach and suggest that changes, especially those focusing on self-efficacy, will strengthen the impact of the program.

However, the intervention program revealed a significant improvement in geometry achievement, indicating an effective and precise intervention program for changing and improving geometry teaching.

A significant decrease in mathematics anxiety was observed, due to the program's built-in support for stress management and building self-confidence. A significant reduction in test anxiety (situational anxiety) was also observed, which is very helpful for students. Reducing test anxiety is critical, as it not only improves performance but also promotes a more constructive approach to learning. Interestingly, the pilot study did not show significant increases in self-efficacy, which may indicate that self-efficacy benefits from longer-term interventions or may require more focused support strategies. This finding highlights an area for future program development and suggests that additional components specifically aimed at strengthening self-efficacy may be valuable. Future research on expanding the sample to include diverse student populations, such as special education students with dyscalculia, or younger students, would allow for broader generalization of the results.

Also, to test the program in other subject areas. Therefore, the positive impact of the intervention on mathematics performance highlights the value of integrating emotional and academic strategies, which can support learning and create personal balance. Furthermore, this pilot study provided a strong basis for improving and expanding the program to better support students' emotional and academic growth in mathematics.

Overall, the pilot study findings confirm the potential effectiveness of the intervention that combines emotional and academic tools.

This pilot study highlights the value of implementing tools that support emotional development in mathematics education while addressing emotional factors such as anxiety, which can significantly affect student performance and achievement. The results show that while the intervention led to significant improvements in student achievement in mathematics and reduced anxiety, further refinement is needed to increase its impact on self-efficacy. As a result, several changes were made to the pilot program to streamline the main study.

These adjustments included reorganizing student worksheets and integrating emotional and academic exercises into each worksheet. Each task was embedded in a presentation link, given a specific time limit, encouraging students to focus and complete with organization and punctuality. In addition, more variety was introduced in reflective writing tasks, including a progress reflection for each lesson. This reflection included student self-assessment and teacher feedback aimed at reinforcing learning. Insights from this phase helped develop a stronger and more focused intervention for the main study, which is now better equipped to support students' academic and emotional growth.

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Appendix 1- Student Interview

The interview is anonymous and will be used for research purposes only!!

Thanks in advance for your cooperation!

Student's name: _____ Class_____ :

Do you feel an improvement in your performance and achievements?

_____

To what extent are you able to apply the principles and tools learned in the Geometry classes?

_____

Do you believe that you are more capable of handling tasks in Geometry today than in the past?

_____

Which tool helped you the most? _____

Today, are you able to set educational goals for yourself and meet them?

_____

What is the importance of geometry classes in your opinion?

_____

Do you feel you have the knowledge and tools to tackle challenging tasks?

_____

Do you feel that your relationship with Geometry classes has improved?

_____

In which areas of yours did you expect to see a change in performance, and the change did not happen ?

_____

What component of the intervention plan made you change the most?

_____

What suggestions you have for improvement?

_____

How the tools learned can be applied?

_____

Do you think it is important to spread the program to more classes and more schools?

_____

What do you think causes students math anxiety?

_____

Thanks, Dikla Polacco