

MATHEMATICAL ANXIETY MITIGATION THROUGH THE DEVELOPMENT OF SELF-REGULATED LEARNING SKILLS

Amal Sharif-Rasslan¹, & Amtiaz Fattum²

¹Department of Mathematics, The Academic Arab College of Education (Israel)

²Department of Computer Science, The Academic Arab College of Education (Israel)

Abstract

Self-Regulated Learning (SRL) refers to how people manage their personal learning processes, specifically how to monitor, regulate, and evaluate their learning and plan learning actions and behavioral processes that increase the likelihood of goal achievement (Zimmerman, 2008). Mathematics Anxiety (MA) refers to the experience of fear and nervousness when participating in mathematical tasks. MA is a barrier to mathematical learning and is considered to hinder student engagement and the effectiveness of their metacognitive processes. Some scholars claimed that very few comprehensive studies link MA and metacognition or SRL in the secondary school context (Efklides, 2011; Morsanyi et al., 2019). Parveen and others (Parveen et al., 2023) suggested future research to explore the relationship between motivation, MA, mathematical learning, and mathematics perseverance. The aim of this study is to explore the impact of adopting an intervention program of the SRL skills on mathematical anxiety among high secondary school students. Sixty-eight 12th graders who learned mathematics at low learning level, aged (M=17.34, SD=0.43), and studied according to an intervention program that was developed for the purpose of this study and based on practicing SRL skills while solving mathematical problems crossing the SRL stages following (Zimmerman, 2008), the learner: a) makes plans before starting to learn; b) monitors and regulates his cognition, motivation and behavior during the learning process; c) reflects on his learning process afterwards. Two (pre and post) mathematical achievement questionnaires (Matriculation exams preparation), Hopko (2003) MA questionnaire (was distributed pre and post intervention), and a questionnaire that examines the relationship between SRL and mathematical achievement was distributed post intervention. The findings indicated that the average of the students' achievements before the intervention program (M=50.16, SD=24.25), is significantly lower than the average of their achievements after the intervention (M=65.47, SD=20.41), $t=-9.047$, $p<0.01$. In addition, it was found that the students' MA before intervention (M=29.87, SD=9.44) was significantly higher than students' MA after the intervention (M=18.22, SD=6.13), $t=23.75$, $p<0.01$. Moreover, there is a significant weak positive correlation between SRL and mathematics achievements, $r_p=0.309$, $p<0.05$. This study offers both theoretical and practical contributions. Theoretically, the findings elucidate the role of SRL in mathematical cognition and performance. Practically, the study informs pedagogical strategies by underscoring the importance of fostering SRL in mathematics education and to reduce the level of MA and to increase their academic achievements.

Keywords: *Self-regulated learning, mathematics achievements, mathematical anxiety.*

1. Introduction

The constructivist learning theory is grounded in the active interaction between individuals and their environment, where knowledge is actively constructed by the learner. This process results in a personalized understanding of the world. Several learning models have emerged from this foundational idea, one of which is the Self-Regulated Learning (SRL) approach. In SRL, the student assumes responsibility for regulating and directing their own learning process. SRL is conceptualized as an active, cyclical process of self-management, encompassing key components such as planning, goal setting, self-monitoring, and reflection. These processes are informed both by the learner's intrinsic factors (e.g., cognition, motivation, emotion) and by the external learning environment, which includes physical and social contexts (Pintrich, 2000). For optimal development of learning and daily functioning, students must engage in their self-regulation skills. A lack of self-regulation in cognitive, emotional, and behavioral domains can hinder a student's ability to successfully complete academic tasks (Florez, 2011). There is

substantial empirical evidence supporting the idea that metacognitive skills are essential for effective and efficient learning, serving as a critical foundation for academic success (Schraw et al., 2006; Zimmerman, 2000).

Anxiety is a psychological symptom that can manifest in any individual. This phenomenon is observed in some students within the school environment, where anxiety is frequently associated with academic difficulties. Mathematics is a subject that many students find particularly challenging. For some, it is perceived as one of the most difficult disciplines, leading them to actively avoid it. As a result, students often experience heightened anxiety when faced with mathematical tasks (Anindyarini & Supahar, 2019).

Studies have highlighted the effectiveness of metacognitive training programs, which concentrate on problem-solving approaches in mathematics, in reducing anxiety among secondary school students (Veenman et al., 2000). Many studies suggest that MA may be driven by teaching methods that prioritize rote memorization of foundational skills, rather than those that emphasize problem-solving, understanding, and reasoning. However, there has been limited investigation into the relationship between anxiety and cognitive processes within the context of mathematics education (Kramarski et al., 2010).

2. Objectives

The purpose of this study is to examine the relationship between SRL and MA, as well as the effect of implementing an SRL teaching intervention program on MA among 12th-grade students.

Research Questions

1. Is there a difference in students' mathematical achievement before and after adopting the SRL teaching approach?
2. Is there a difference in the level of mathematics anxiety before and after the adoption of the SRL teaching approach?
3. Is there a relationship between the SRL teaching approach and MA? How is this relationship manifested?

3. Methodology

This study was designed quantitatively. The participants' academic achievements and MA levels were compared to pre and post intervention programs.

3.1. Participants

Sixty-eight 12th graders (41.2% males and 58.8% females) participated in this study. Those participants were chosen randomly out of 182 twelfth graders who learned mathematics at a low learning level according to the mathematics curriculum. The participants aged ($M=17.34$, $SD=0.43$), and studied according to an intervention program that was developed for the purpose of this study and based on practicing self-regulated learning skills while solving mathematical problems crossing the SRL stages following (Zimmerman, 2008), the learner: a) makes plans before starting to learn; b) monitors and regulates his cognition, motivation and behavior during the learning process; c) reflects on his learning process afterwards.

3.2. Instruments

In this study, the following instruments were used:

- a. Two (pre, and post) mathematical academic achievement questionnaires (Matriculation exams preparation). The researchers developed both tests in alignment with the mathematics curriculum and previous matriculation exams. Content validity for both exams was established through expert review by the school's mathematics coordinator and an academic specializing in mathematics education
- b. Hopko (2003) MA questionnaire (was distributed pre and post intervention program). Both questionnaires included 12 items. Students were asked to respond to the various items using a Likert-type scale consisting of five levels (0=not at all stressed; 1=a little stressed; 2=stressed; 3=a lot stressed; 4=very much stressed). The degree of anxiety was calculated by summing up the points of all the items. The higher the sum, the higher the level of anxiety (it is worth noting that the highest sum is 48). The degrees of anxiety were determined as follows: 0 Low degree: 1-12, Moderate degree: 13-24, Moderate degree: 25-36, High degree: 37-48. The reliability of the questionnaire according to Cronbach's alpha, was: $\alpha=0.847$ before the intervention, and $\alpha=0.759$ after the intervention.

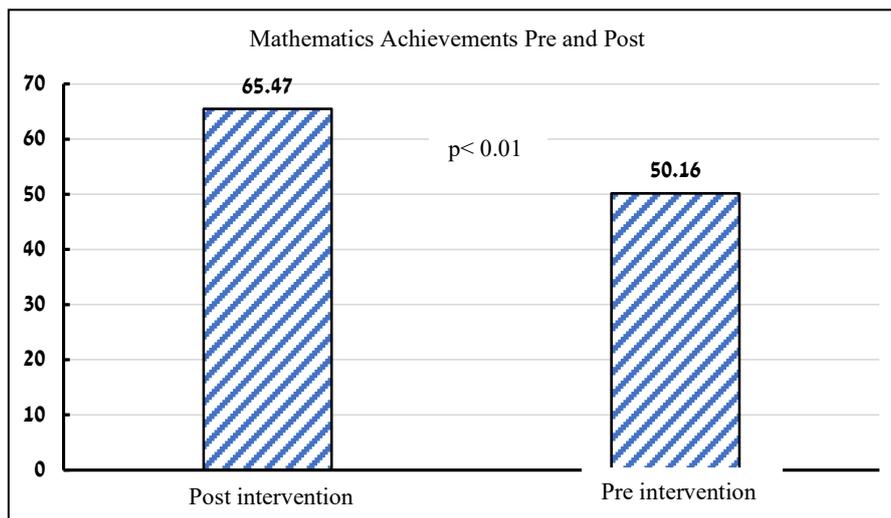
- c. A questionnaire that examined the relationship between SRL and mathematical achievement was distributed post intervention. This questionnaire included 28 items relating to SRL and academic achievement. Students were asked to respond to the various items using a Likert-type scale consisting of five levels: (1=never; 2=rarely; 3=very often; 4=often; 5=always). The SRL level was determined by calculating the average of the participant's responses to all items. The reliability of the questionnaire $\alpha=0.743$, was determined using Cronbach's alpha.

4. Results

4.1. Mathematics academic achievements

There was a significant difference with a large effect size between the students' achievement average before the intervention program ($M=50.16$, $SD=24.25$) and their average after the intervention program ($M=65.47$, $SD=20.41$), ($t=-9.047$, $p<0.01$, Cohen's $d=0.683$), Figure 1.

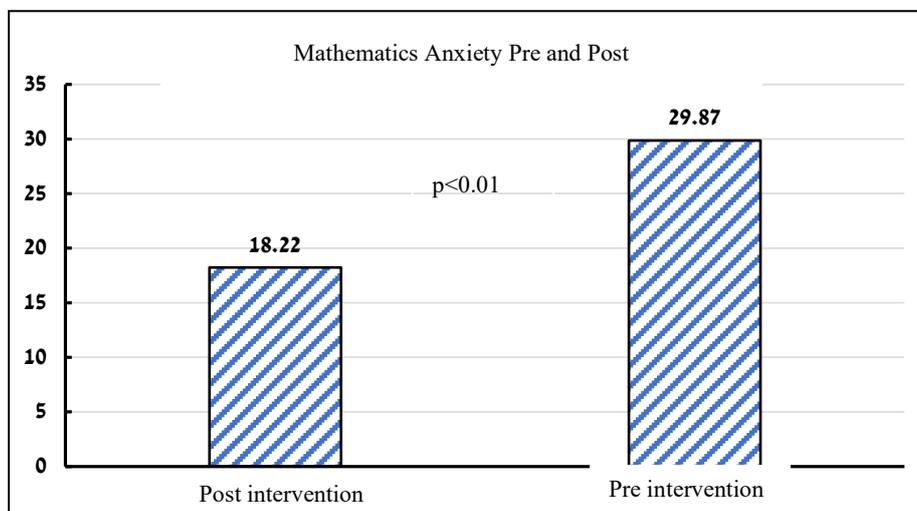
Figure 1. Mathematics Achievements Pre and Post.



4.2. Mathematics anxiety

There was a significant difference with a very large effect size between the students' MA level before the intervention ($M=29.87$, $SD=9.44$) and their MA level after the intervention ($M=18.22$, $SD=6.13$), ($t=-23.75$, $p<0.01$, Cohen's $d=1.46$), Figure 2.

Figure 2. Mathematics Anxiety Pre and Post.



4.3. SRL and Mathematics achievements

There is a significant weak positive correlation between SRL and mathematics academic achievements, $r_p=0.309$, $p<0.05$.

5. Discussion

The research literature consistently indicates that students' attitudes toward mathematics are significantly influenced by their school learning environment, which in turn shapes their mathematical understanding and application in both academic and real-world contexts. A pivotal principle in contemporary education is fostering SRL, wherein students take initiative in their learning processes, engage in inquiry, regulate their cognitive strategies, and develop metacognitive awareness (Pokhrel & Sharma, 2024). This framework provides a theoretical rationale for the observed improvement in student achievement following the implementation of an intervention program. The program equipped students with both cognitive and metacognitive skills, which functioned as tools for comprehending and solving mathematical problems effectively, thereby contributing to enhanced academic performance.

Our findings indicated that there was a significant difference with a very large effect size between the students' MA level before and after the intervention program. In other words, MA was reduced as a result of the SRL approach. This finding is supported by previous studies that claimed that implementing SRL approaches in mathematics education can effectively reduce MA by fostering self-efficacy, enhancing metacognitive awareness, and promoting emotional regulation. Educators are encouraged to integrate SRL techniques into their teaching practices to support students in overcoming math anxiety and achieving better mathematical outcomes (Kramarski et al., 2010, Hendral & Hidayati, 2023).

Moreover, our findings indicated that there was a significant weak positive correlation between SRL and mathematics achievements. This finding is supported by research literature, which indicates that SRL fosters mathematical thinking strategies that allow students to arrive at correct solutions independently and efficiently, which increases his/her academic mathematics achievement, and that high levels of SRL are associated with reduced MA, while lower levels are linked to increased MA. These findings highlight the importance of integrating SRL into mathematics education to reduce MA and enhance academic performance (Harahap et al., 2025). Furthermore, SRL supports the development of metacognitive abilities such as planning, monitoring, and evaluating problem-solving processes. These skills help reduce MA by increasing students' sense of control and self-confidence (Turgut & Bakır, 2024).

6. Conclusions

This study offers both theoretical and practical contributions. Theoretically, the findings elucidate the role of SRL in mathematical cognition and performance. Practically, the study informs pedagogical strategies by underscoring the importance of fostering SRL in mathematics education and reducing the level of MA and increasing their academic achievements.

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