Iranian Evolutionary Educational Psychology Journal
IEEPJ
University of Hormozgan
Online ISSN: 2588 - 4395
Homepage: https://ieepj.hormozgan.ac.ir

The Effect of Teaching Problem-Solving Strategies on Academic Self-Regulation and Math Anxiety among Sixth Grade Male Students

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Article Info

Article type:
Research Article

Article history:
Received 25 Jan. 2025
Received in revised form 10 Mar. 2025
Accepted 06 Apr. 2025
Published online 01 Jun. 2025

Keywords:
Teaching problem-solving strategies,
Academic self-regulation,
Mathematics anxiety,
Elementary schools' students

ABSTRACT

Objective: The objective of the current investigation was to examine the influence of instructing problem-solving strategies on the academic self-regulation and mathematical anxiety of male sixth-grade students enrolled in elementary schools in Bushehr.

Methods: The methodology employed in this study was of a semi-experimental nature. The statistical population for this research comprised 2113 male sixth-grade elementary school students in Bushehr. The sample utilized in the study consisted of 40 individuals selected through cluster random sampling techniques. The instruments for data collection included the Bouffard (1995) Academic Self-Regulation Questionnaire and the Math Anxiety Questionnaire developed by Chiu and Henry (1990).

Results The findings indicated that the instruction of problem-solving strategies significantly enhanced the academic self-regulation of participants in the experimental group when compared to control group. Furthermore, the instruction of problem-solving strategies was found to diminish the mathematical anxiety of participants in the experimental group in comparison to the control group.

Conclusions: Overall, the implementation of problem-solving strategies, through enhancements in self-regulation and reductions in anxiety, lays the groundwork for improved academic achievement and heightened engagement in the field of mathematics.

Cite this article: Khorshidi, M. M., Mardani, A. & Mirzaee Azandaryani, B. (2025). The effect of teaching problem-solving strategies on academic self-regulation and math anxiety among sixth grade male students. *Iranian Evolutionary Educational Psychology Journal*, 7 (1), 1-14.
DOI: https//doi.org/ 10.22034/7.2.1

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Introduction

Mathematics holds a central position in the educational curricula of all countries due to its critical role in fostering logical reasoning and cognitive development among students. As a foundational discipline for the sciences and engineering, mathematics is afforded special emphasis within global education systems. Consequently, ensuring student success in this subject and addressing potential academic underperformance have become major priorities (Escalera-Chávez et al., 2019). Furthermore, in today's world, students across all fields increasingly require numerical and analytical skills for daily problem-solving. Math anxiety, defined as a sense of unease or distress experienced when engaging in mathematical tasks, has been a longstanding area of concern in educational research. It has been examined extensively since the early 20th century and remains a pressing issue in the academic development of children and adolescents (Aghasaleh et al., 2024; Moradi et al., 2022).

In parallel, problem-solving strategies are essential life skills that not only contribute to academic success but also play a crucial role in enhancing students' interpersonal and social competencies. Students are frequently confronted with various challenges, and without effective coping mechanisms, these can lead to psychological distress. Implementing structured problem-solving strategies serves as a protective factor. Although all students possess some level of inherent problem-solving ability, the challenge often lies in overcoming the inclination to seek immediate or superficial solutions (Ergen, 2020). Proper instruction in this domain can significantly support students, particularly when facing mathematical problems.

Problem-solving involves a systematic mental process of identifying, analyzing, and resolving issues. Its primary objective is to navigate barriers and arrive at the most effective solutions. In certain cases, students are required to build upon their existing knowledge base to address the problem at hand. These strategies promote critical thinking by encouraging the consideration of multiple approaches and the selection of the most suitable one. Adhering to the structured steps of problem-solving not only fosters analytical thinking but also leads to more efficient and accurate resolutions. The importance of these skills is such that teaching them is considered a parental responsibility, equipping children to manage various life challenges effectively. Indeed, problem-solving competence is widely recognized as one of the most vital skills for lifelong success, as supported by numerous studies (Zhou et al., 2020).

Another critical dimension influencing educational outcomes is academic self-regulation. This construct reflects an individual's ability to employ strategic processes to guide their learning towards personal goals (Behzadi Soufiani et al., 2023). Self-regulated learning not only enhances academic performance but also empowers learners to take an active role in managing tasks such as setting goals, monitoring progress, evaluating outcomes, and sustaining motivation. The implications of self-regulation extend beyond the classroom, contributing to overall life success (Guilmette et al., 2019).

According to Schunk and Zimmerman (2011), self-regulation encompasses various behaviors, including effective time management, sustained attention during learning, strategic organization and review of information, creation of productive work environments, and the use of supportive social networks. By learning these strategies, students can improve their focus, persistence, and ability to achieve learning objectives. Furthermore, self-regulated learners are equipped to engage in metacognition, which involves the active monitoring of one's own learning process, recognizing internal and external factors that may hinder progress.

However, since students vary in their capacity for self-monitoring and reflection, educators play a crucial role in cultivating metacognitive awareness. It is essential for teachers to encourage students to recognize that learning is an intentional and effortful endeavor. By fostering this mindset, students are more likely to adopt effective learning strategies and become autonomous, motivated learners (Parry et al., 2020).

Mathematics anxiety refers to a negative psychological mindset toward solving mathematical problems that significantly affects students' learning approaches and academic outcomes (Habibi Khouzani et al., 2023). As fear and anxiety related to mathematics increase, students' efficiency in solving mathematical problems and their use of effective problem-solving strategies decline, particularly among children and adolescents. This highlights the crucial role of problem-solving ability in mathematics—a role so central that many equate it directly with the discipline itself. One of the primary goals of mathematics education is to enhance students' capacity to solve a wide range of complex mathematical problems (Son & Fatimah, 2020).

Mathematics anxiety is influenced by nearly all aspects of mathematics teaching and learning, both directly and indirectly. It can stem from students' previous negative experiences with math learning, whether in the classroom or at home. Consequently, the issue of mathematics anxiety and

its study has emerged as a significant concern in the national education system. Mathematics anxiety typically surfaces in evaluative or problem-solving contexts and is characterized by self-doubt regarding performance and its consequences, along with a marked reduction in the individual's capacity to cope with such situations.

In recent years, the concept of math anxiety has garnered considerable attention from researchers and math educators. Notably, most studies on this topic have focused on the elementary school level—an important finding, given that students' attitudes toward mathematics are shaped in early childhood. Researchers have observed that math anxiety often begins in primary school and persists throughout students' educational trajectories (Li et al., 2021).

Furthermore, a review of both Iranian and international studies in this field reveals a research gap: there has been no comprehensive study examining the effect of teaching problem-solving strategies on students' academic self-regulation and math anxiety. Prior investigations have largely focused on adjacent topics. Studies by Babazadeh et al. (2021), Mami et al. (2014), Veyskarami et al. (2021), Santos-Trigo (2020), Zhou et al. (2020), Sawyer et al. (2021), ten Braak et al. (2019), Wagner et al. (2021) and Vukovic et al. (2013) have highlighted the impact of problem-solving strategy instruction on various aspects of students' academic performance.

In terms of the significance and necessity of the current research, it is important to note that one of the fundamental aims of mathematics textbooks is to engage students in the problem-solving process and enhance their competence in this area. The activities within these textbooks are primarily designed to serve this purpose. Students are intentionally and consciously exposed to problem situations in these books. Moreover, mathematical discourse in the classroom—which helps address student misconceptions—requires focused attention on the problem-solving process. On the other hand, deficiencies in instructional quality often deprive students of the opportunity to fully understand the underlying concepts of mathematics. As a result, students are compelled to memorize rules and solutions without truly grasping them. If a student lacks strong memory skills, they may forget the memorized content at any moment, leading to confusion and ultimately to mathematics anxiety.

Mathematics anxiety significantly impacts students' academic success throughout their education and life, as mathematics is closely linked to numerous occupations and daily personal tasks. Therefore, there is an urgent need to investigate the contributing factors and explore specific

instructional strategies that can reduce students' mathematics anxiety. Generally, poor academic achievement in mathematics is one of the most prevalent issues within the national educational system, observed across all educational levels—particularly in elementary school. Many students experience mathematics anxiety to such an extent that some even admit to fearing the subject.

Hence, if the findings of this research demonstrate that teaching problem-solving strategies can effectively reduce mathematics anxiety among students, the study will help clarify the complexities of this issue. It will also provide practical insights for psychologists, school counselors, and educational specialists, who can apply the results to support students more effectively.

The rationale behind conducting this study lies in the significant impact that problem-solving strategy instruction can have on students' academic self-regulation and mathematics anxiety. The principles and methodologies adopted in this research are drawn from highly effective teaching approaches and could be utilized across the educational system and training centers nationwide.

A review of previous research revealed that none of the existing studies have specifically examined the effect of teaching problem-solving strategies on academic self-regulation and mathematics anxiety among sixth-grade male students in Bushehr city. In line with this gap, the present study aims to address the following research question: Does teaching problem-solving strategies influence academic self-regulation and mathematics anxiety in sixth-grade male students in Bushehr?

Material and Methods

This study employed a quasi-experimental research design. The statistical population included 2,113 sixth-grade male elementary school students in Bushehr during the 2023–2024 academic year. Given the size and distribution of the target population, cluster random sampling was employed. Initially, two schools were randomly selected from a total of 48 elementary schools in the city of Bushehr. Then, 40 students were chosen—20 for the experimental group and 20 for the control group.

After obtaining necessary permissions and providing participants with an explanation of the research objectives, the relevant questionnaires were distributed for completion. All personal information and student responses were treated with strict confidentiality, and no identifiable

information was included in the final research report. Additionally, both students and their parents were assured that participation in the study was entirely voluntary, and they were free to withdraw at any time without facing any negative consequences.

Instruments

Data collection tools comprised three components:

Bouffard's Academic Self-Regulation Questionnaire: This questionnaire, developed by Bouffard et al. (1995) based on Bandura's cognitive theory and standardized in Iran by Kadivar, uses a 5-point Likert scale ranging from "strongly agree" (5) to "strongly disagree" (1). Items 5, 13, and 14 are reverse scored. The questionnaire consists of two subscales: cognitive strategies (items 1–7) and metacognitive strategies (items 8–14). Bonneville-Roussy and Bouffard (2015) reported a Cronbach's alpha reliability coefficient of 0.83. In the present study, the reliability was confirmed with a Cronbach's alpha of 0.84. Construct validity, as reported by Bonneville-Roussy and Bouffard (2015), was 0.79 based on criterion validity. In this study, item-total correlations were calculated and showed significant correlations for all items, confirming validity.

Mathematics Anxiety Scale for Children (MASC): This 22-item scale measures four dimensions: math learning anxiety (items 1, 5–9), problem-solving anxiety (items 2, 3, 10, 11, 13, 14), teacher-related math anxiety (items 4 and 12), and math evaluation anxiety (items 15–22) (Chiu & Henry, 1990). Items are rated on a 4-point Likert scale: "none" (0), "low" (1), "somewhat" (2), and "high" (3). Chiu and Henry (1990) reported a Cronbach's alpha of 0.85 for reliability. In this study, the reliability was found to be 0.82. Construct validity was previously reported as 0.86 based on factor analysis. In the present study, all item-total correlations were statistically significant, confirming the validity.

The Socratic method and the mathematical heuristic of George Pólya: The intervention consisted of eight 90-minute sessions during which students in the experimental group received training on problem-solving strategies based on George Pólya's framework (Rhee, 2007). The training content focused on the principles and stages of mathematical problem-solving as outlined by Pólya. Table 1 below presents a summary of the content covered in each training session based on Pólya's model of problem-solving.

Table 1. Summary of the content of problem-solving strategies training sessions based on George Polya's model

Session	Content
1	Pre-test implementation. Training the classroom teacher to implement the method, the four steps, essential skills, learner errors, and planning techniques to develop a lesson plan based on this method.
2	Familiarizing learners with the steps of implementing problem solving based on the George Polya method to the extent of introducing the method and discussing and interacting with students.
3	Solving exercises and mathematical problems through the George Polya problem-solving method. Students are also asked to volunteer to do mathematical problems and use this method and share their answers. At the end of the session, they were given a series of exercises for the next session.
4	At the beginning of the session, the exercises from the previous session were presented in class, and questions were answered and problems were fixed. Then, the learners were introduced to problem-solving strategies for using the four steps of George Polya as best as possible. These strategies were briefly explained in the math book.
5	Discussion and exchange of views on the strategies presented in the previous session and solving exercises through new strategies were discussed.
6	Familiarizing learners with the essential skills of problem solving in the classroom.
7	Familiarize learners with the mistakes they make in problem solving using George Polya's four-step method.
8	Acceptance and Change: Overview of previous sessions and further exercises. -Administering a post-test.

Results

To justify the use of parametric tests, the assumption of normality was assessed using the Kolmogorov-Smirnov test. The results of this analysis are presented in Table 2.

Table 2. Kolmogorov-Smirnov Test Results for the Assumption of Normal Distribution

Variable	Group	Statistic	P
Academic self-regulation	Experimental	0.140	0.60
	Control	0.115	0.30
Math Anxiety	Experimental	0.109	0.20
	Control	0.78	0.40

The Kolmogorov-Smirnov test outcomes (Table 2) indicated that the significance levels for all study variables exceeded 0.05. Therefore, the Kolmogorov-Smirnov statistic was not significant at the 0.05 level, suggesting that the distribution of the variables did not deviate significantly from normality. Based on this finding, all research hypotheses were examined using parametric inferential statistical methods, particularly simultaneous bivariate regression analysis.

Table 3. Mean and Standard Deviation of Academic Self-Regulation and Math Anxiety Scores by Group in Posttest

Variable	Experimental			Control		
	N	Mean	SD	N	Mean	SD
Academic self-regulation	20	48.23	5.83	20	45.50	4.73
Math Anxiety	20	48.75	5.99	20	52.29	6.67

According to the data in Table 3, the mean academic self-regulation score in the experimental group was higher than that of the control group in the posttest phase. Conversely, the mean math anxiety score in the experimental group was lower than that of the control group, suggesting a potential positive effect of the intervention.

Table 4. Summary of Multivariate Analysis of Covariance (MANCOVA) on Posttest Scores for Academic Self-Regulation and Math Anxiety

Effect	Test	Value	F	Hypothesis DF	Error DF	P	Effect size
Group	Pillai's Trace	0.863	33.16	2	38	0.001	0.863
	Wilks' Lambda	0.137	33.16	2	38	0.001	0.863
	Hotelling's Trace	6.31	33.16	2	38	0.001	0.863
	Roy's Largest Root	6.31	33.16	2	38	0.001	0.863

Table 4 presents the results of the multivariate analysis of covariance (MANCOVA) on posttest scores, controlling for pretest scores of academic self-regulation and math anxiety. As shown in the table, there was a statistically significant difference between the experimental and control groups in at least one of the dependent variables ($p < 0.001$). This indicates that problem-solving strategy training led to improvements in academic self-regulation and reductions in math anxiety among participants in the experimental group compared to those in the control group. Therefore, the main research hypothesis was supported.

To further explore these differences, univariate ANCOVA analyses were conducted within the MANCOVA framework for both academic self-regulation and math anxiety.

Table 5. Results of Univariate ANCOVA within MANCOVA

Effect	Variable	SS	DF	MS	F	P	Effect size
Group	Academic self-regulation	289.79	1	289.79	35.57	0.001	0.597
	Math anxiety	202.92	1	202.92	77.95	0.001	0.765

As indicated in Table 5, the results of the univariate ANCOVA showed significant differences between the groups in both academic self-regulation ($F = 35.57$, $p < 0.001$) and math anxiety ($F = 77.95$, $p < 0.001$). These findings confirm that the intervention—problem-solving strategy training—significantly enhanced academic self-regulation and reduced math anxiety in the experimental group compared to the control group.

To better understand the magnitude of these differences, the posttest mean scores of academic self-regulation and math anxiety were compared between the two groups. As seen in Table 3, the experimental group reported higher academic self-regulation and lower math anxiety scores than

the control group, providing further evidence for the positive impact of problem-solving training on these educational and psychological outcomes.

Discussion

The present study aimed to investigate the effect of problem-solving strategy instruction on academic self-regulation and math anxiety among sixth-grade male elementary students in Bushehr. The results revealed that the mean score of academic self-regulation in the experimental group during the posttest phase was higher than that of the control group, whereas the mean math anxiety score was lower in the experimental group compared to the control group. In other words, problem-solving strategy training significantly improved academic self-regulation and reduced math anxiety in the experimental group relative to the control group.

These findings are consistent with previous research conducted by Babazadeh et al. (2021), Mami et al. (2014), Veyskarami et al. (2021), Santos-Trigo (2020), Zhou et al. (2020), Sawyer et al. (2021), ten Braak et al. (2019), Wagner et al. (2021) and Vukovic et al. (2013). Analysis and interpretation of the findings suggest that instruction in problem-solving strategies—such as understanding the problem, designing a solution, executing the solution, and reviewing the process—helps students actively manage their learning. This aligns with the core components of academic self-regulation, including goal-setting, planning, monitoring, and self-evaluation.

Furthermore, when students learn to break a problem into smaller components and develop appropriate solutions for each stage, they gain a greater sense of control over their tasks and experience lower levels of anxiety. The increase in academic self-regulation following the training suggests that students became more responsible for their own learning by applying skills such as planning, self-monitoring, and self-assessment. On the other hand, the reduction in math anxiety indicates that structured and sequential training in problem-solving skills can alleviate students' fears and concerns about challenging subjects like mathematics, thereby fostering a greater sense of efficacy and confidence.

From this, it can be concluded that teaching problem-solving strategies is an effective and practical approach to enhancing learning quality, increasing academic self-regulation, and reducing emotional challenges such as anxiety. Therefore, it is recommended that this type of instruction be integrated into elementary school curricula, particularly within mathematics education. The

observed improvement in academic self-regulation indicates that students, through learning problem-solving strategies, developed better skills in goal-setting, study planning, learning behavior monitoring, and performance evaluation. This finding supports theories of self-regulated learning, which emphasize the active role of learners in managing their own cognitive, motivational, and behavioral processes.

Moreover, the significant reduction in math anxiety among students in the experimental group suggests that problem-solving instruction can play a key role in improving attitudes toward mathematics and reducing negative emotional responses associated with the subject. A major cause of math anxiety is the experience of failure in solving problems and feelings of inadequacy. However, when students become familiar with a step-by-step, structured, and purposeful approach to problem-solving, they develop a stronger sense of control and mastery, which leads to reduced anxiety. Math anxiety is often rooted in a lack of perceived control, negative prior experiences, and self-doubt regarding one's cognitive abilities in mathematics. When students are introduced to problem-solving strategies and learn the necessary skills to manage the problem-solving process, their sense of incompetence and helplessness is diminished. Consequently, their confidence increases, and anxiety is reduced.

Problem-solving strategies serve not only as educational tools for improving academic performance but also as influential factors in psychological growth, motivational enhancement, and emotional regulation in the learning process. As such, the inclusion of such training in elementary school curricula—particularly in mathematics—is strongly recommended to both strengthen learning skills and prevent issues like academic anxiety.

The findings of this study suggest that problem-solving strategy instruction can significantly enhance students' academic performance while also playing a crucial role in developing psychological and emotional self-regulation skills. Given that mathematics is a particularly anxiety-inducing subject for many elementary students, strengthening cognitive abilities through problem-solving training can serve as an effective educational intervention to improve their attitudes and performance in math.

However, the study was limited by the short-term nature of follow-up and constraints on random sampling, which should be considered when interpreting the results. For future research and practical application, it is recommended that elementary mathematics teachers incorporate

structured problem-solving strategy instruction as part of the regular curriculum. Furthermore, professional development workshops focusing on cognitive and metacognitive strategies should be designed and implemented for teachers. In addition, curriculum developers should prioritize the cultivation of problem-solving and self-regulation skills as essential competencies within textbook content and educational materials.

It is also advisable to integrate step-by-step problem-solving strategies (such as self-questioning, drawing diagrams, etc.) into daily mathematics instruction and to reinforce academic self-regulation skills through exercises like individual goal-setting, study planning, progress evaluation, and feedback delivery.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by ethics committee of Islamic Azad University.

Author contributions

All authors contributed to the study conception and design, material preparation, data collection and analysis. All authors contributed to the article and approved the submitted version.

Funding

The authors did (not) receive support from any organization for the submitted work.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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