International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Metacognitive-Based Lesson Design in Reducing Students' Mathematics Anxiety in Statistics and Probability

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Abstract: ***Mathematics anxiety remains a persistent barrier to effective learning and performance in mathematics education, prompting the need for instructional interventions that address both cognitive and affective dimensions of learning. This study determined the level of students' mathematics anxiety, developed and validated Metacognitive-Based Lessons (MBL), and tested their effectiveness in reducing mathematics anxiety among learners. A descriptive-developmental with a pre-experimental design, convergent mixed-methods approach was employed, integrating quantitative data from pre-test and post-test anxiety scores with qualitative insights from expert feedback and student reflections in support to the effectiveness of MBL. Results revealed that students initially exhibited a high level of mathematics anxiety (M ≈ 3.83), particularly in tasks involving tests, worksheets, and problem-solving activities, indicating that anxiety significantly affected their engagement in mathematics. In response, Metacognitive-Based Lessons were developed following the DepEd lesson format. Expert validation showed that the MBL obtained high ratings in terms of Planning and Objectives, Lesson Design, Learning Activities and General Remarks confirming its appropriateness for classroom use. Furthermore, post-test results indicated a significant reduction in mathematics anxiety (M ≈ 1.94), with statistical analysis confirming a significant difference between pre-test and post-test scores, demonstrating the effectiveness of the intervention. The MBL was found to be valid, effective, and responsive in addressing mathematics anxiety.***

Keywords: metacognitive-based lessons, metacognitive strategies, mathematics anxiety, self-regulated learning, teaching effectiveness

1. Introduction

Developing effective instructional approaches in mathematics requires careful consideration of both cognitive and affective dimensions of learning. In particular, addressing students' mathematics anxiety and enhancing their learning experiences necessitates strategies that promote active engagement, reflection, and self-regulation. One promising approach highlighted in educational research is the integration of metacognitive strategies in lesson development.

Students' Mathematics Anxiety

Mathematics anxiety is a well-documented affective condition characterized by feelings of tension, fear, and worry when individuals engage in mathematical tasks (Richardson & Suinn, 1972; Ashcraft, 2002; Beilock, 2010). In both international and local contexts, studies have consistently shown that mathematics anxiety is prevalent among students and significantly affects their learning experiences (Dowker et al., 2019; Villafuerte, 2021). These emotional responses interfere with cognitive processes, particularly working memory, which is essential for understanding concepts and solving problems (Ashcraft & Krause, 2007; Beilock, 2010). As a result, learners with high levels of mathematics anxiety experience difficulty organizing information, recalling prior knowledge, and applying appropriate problem-solving strategies, leading to decreased academic performance and reduced participation in mathematical activities (Ramirez et al., 2013; Foley et al., 2020; Bernardo, 2005). Mathematics anxiety is not merely a situational response but a persistent affective factor that significantly influences students' engagement, performance, and long-term attitudes toward mathematics. Over time, it develops into a stable disposition that shapes learners' academic trajectories and avoidance behaviors in mathematics-related tasks (Dowker et al., 2019; Foley et al., 2020).

Recent literature further confirms that mathematics anxiety is strongly associated with reduced working memory efficiency and impaired problem-solving performance (Ramirez et al., 2021; Barroso et al., 2021; Zhang et al., 2022; Wang et al., 2023). These findings highlight that affective factors directly influence cognitive functioning, thereby affecting learning outcomes in mathematics. Students who experience anxiety tend to disengage from challenging tasks, avoid participation, and demonstrate lower persistence when solving complex problems. Consequently, their opportunities to develop conceptual understanding and mathematical competence are significantly reduced.

From an educational perspective, mathematics anxiety represents a critical barrier to effective learning that requires deliberate instructional attention. In mathematics education, where reasoning, problem-solving, and conceptual understanding are central, emotional readiness is as essential as cognitive preparedness. Addressing mathematics anxiety, therefore, becomes a foundational concern in designing instructional strategies that support both cognitive development and affective well-being of learners.

This aligns with the policies of the Department of Education (Philippines), particularly DepEd Order No. 21, s. 2019, which emphasizes the development of holistic learners by integrating cognitive, affective, and socio-emotional dimensions in instruction. It also supports DepEd Order No. 42, s. 2016, which encourages learner-centered and reflective teaching practices, including instructional approaches that promote higher-order thinking skills and learner engagement.

Moreover, this study contributes to Sustainable Development Goal 4: Quality Education, which promotes inclusive and equitable quality education and lifelong learning opportunities for all. By addressing mathematics anxiety, learners are provided with supportive instructional environments that enhance both cognitive achievement and emotional well-being. In addition, it supports Sustainable Development Goal 3: Good Health and Well-Being, by recognizing the importance of mental and emotional health in the learning process. Reducing mathematics anxiety not only improves academic performance but also strengthens students' psychological well-being, resilience, and positive attitudes toward learning.

Students' Metacognitive Thinking Process

Metacognition, commonly defined as "thinking about one's own thinking," plays a crucial role in students' ability to regulate learning and manage mathematics anxiety (Flavell, 1979; Brown, 1987). It involves two key components: knowledge of cognition- referring to learners' awareness of their strategies, strengths, and limitations—and regulation of cognition, which includes planning, monitoring, and evaluating one's learning processes (Schraw & Dennison, 1994; Schraw & Moshman, 1995). These metacognitive processes enable students to become more strategic and reflective learners, particularly in complex domains such as mathematics, where problem-solving requires continuous assessment and adjustment of thinking strategies (Veenman et al., 2006; Zimmerman, 2002; Efklides, 2021).

Empirical studies have shown that students who demonstrate strong metacognitive skills are better able to approach complex mathematical tasks systematically, leading to improved performance and reduced anxiety (Veenman et al., 2006; Zimmerman, 2002; Efklides, 2021). These learners actively reflect on their problem-solving strategies, adjust their approaches when difficulties arise, and develop greater confidence in handling mathematical challenges. Recent research further emphasizes that metacognitive awareness is strongly associated with academic resilience and self-regulated learning, particularly in STEM-related subjects where cognitive demands are high (Dignath & Büttner, 2018; Schunk & Greene, 2018).

Research further indicates that metacognitive instruction significantly enhances students' mathematical understanding and problem-solving abilities. For instance, studies by Desoete et al. (2001) and Kramarski & Mevarech (2003) highlight that learners who are explicitly taught metacognitive strategies- such as self-questioning, error analysis, and reflective journaling- demonstrate higher achievement and lower levels of anxiety compared to those who receive traditional instruction. Reflective journaling, in particular, has been widely recognized as an effective metacognitive tool that supports self-awareness and emotional regulation in learning (Moon, 2006; Rodgers, 2014). Similarly, Barry J. Zimmerman emphasizes that metacognitive regulation fosters self-efficacy, enabling students to persist despite difficulties and view challenges as opportunities for growth rather than sources of stress.

2. Research Questions

This study developed, validate and test the effectiveness of Metacognitive-Based Lessons (MBL) in reducing Grade 11 students' mathematics anxiety in Statistics and Probability at Tabaco National High School. The following are the specific objectives (1) determine the level of students' mathematics anxiety;(2) develop Metacognitive-Based Lessons (MBL) to address students' mathematics anxiety;(3) validate the developed Metacognitive-Based Lessons (MBL);(4) test the effectiveness of the developed Metacognitive-Based Lessons (MBL) in reducing students' mathematics anxiety; and (5) enhance the validated Metacognitive-Based Lessons (MBL).

3. Methods

The study employed a descriptive-developmental research design combined with a pre-experimental one-group pretest–posttest design. The development of instructional materials followed the ADDIE Model, which includes Analysis, Design, Development, Implementation, and Evaluation phases. A purposive sample of 30 Grade 11 students exhibiting moderate to high levels of mathematics anxiety participated in the study, along with 10 expert validators composed of mathematics teachers and content specialists. Data were gathered using the Modified Abbreviated Math Anxiety Scale (MAMAS), a researcher-made Expert Validation Instrument with a high validity index of 94.5%, and student reflective journals. Quantitative data were analyzed using paired-samples t-tests to compare pre-test and post-test results, while Cohen's d was used to determine effect size. Qualitative data from reflective journals were analyzed to provide deeper insights into students' learning experiences.

4. Results

The pre-test results revealed that students experienced high levels of mathematics anxiety across all tasks, with an overall mean of 3.83, particularly in situations involving difficult homework and surprise quizzes. The developed Metacognitive-Based Lessons (MBL) were rated as highly valid by experts, with an overall validity score of 94.5% and strong interrater reliability of 0.82. Key instructional features included KWL charts, think-aloud modeling, and self-regulation checklists. After the implementation of the MBL, post-test results showed a significant reduction in mathematics anxiety, with an overall mean of 1.94, indicating a shift from high to low anxiety levels. The paired-samples t-test yielded a statistically significant result ($t = 13.31$, $p < 0.001$), confirming the effectiveness of the intervention. Furthermore, the computed effect size (Cohen's d = 2.41) indicated a very large practical impact of the intervention on reducing mathematics anxiety.

5. Discussion

The high baseline level of mathematics anxiety supports the notion that it is a significant barrier in learning Statistics and Probability. These findings are consistent with Ashcraft's

(2002) theory, which explains that anxiety consumes working memory resources, thereby impairing performance, and Flavell's (1979) Metacognition Theory, which emphasizes that awareness and regulation of thinking processes enhance learning outcomes. The effectiveness of the Metacognitive-Based Lessons can be attributed to their structured progression from guided learning to independent problem-solving through scaffolding and cooperative learning. Activities such as KWL charting and self-monitoring checklists helped students develop a sense of control over their learning, reducing feelings of helplessness and anxiety. Additionally, expert-recommended enhancements such as real-life contextualization further improved student engagement and conceptual understanding.

6. Conclusions and Recommendations

The study concludes that Metacognitive-Based Lessons are highly effective in reducing students' mathematics anxiety while enhancing their confidence and problem-solving abilities. It is recommended that mathematics teachers integrate metacognitive strategies such as planning prompts, self-monitoring tools, and reflective journaling into daily instruction to support both cognitive and emotional learning outcomes. Future research is encouraged to conduct longitudinal studies to examine the long-term effects of Metacognitive-Based Lessons and to explore their effectiveness across different mathematical domains and learner populations.

References:

[1] Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181–185. https://doi.org/10.1111/1467-8721.00196
[2] Beilock, S. L. (2010). *Choke: What the secrets of the brain reveal about getting it right when you have to*. Free Press.
[3] Dignath, C., & Büttner, G. (2018). Assessing self-regulated learning in primary school children. *Metacognition and Learning, 13*, 223–258.
[4] Desoete, A., Roeyers, H., & Buysse, A. (2001). Metacognition and mathematical problem solving. *Journal of Learning Disabilities, 34*(5), 435–449.
[5] Dowker, A., Sarkar, A., & Looi, C. Y. (2019). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology, 10*, 95. https://doi.org/10.3389/fpsyg.2019.00095
[6] Flavell, J. H. (1979). Metacognition and cognitive monitoring. *American Psychologist, 34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906
[7] Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2013). On the relationship between math anxiety and math achievement. *Journal of Experimental Psychology: General, 142*(1), 118–125.
[8] Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety and classroom climate. *Journal of Educational Psychology, 110*(2), 141–154.
[9] Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale. *Journal of Counseling Psychology, 19*(6), 551–554.
[10] Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*(4), 460–475.
[11] Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351–371.
[12] Veenman, M. V. J., Van Hout-Wolters, B. H. A. M., & Afflerbach, P. (2006). Metacognition and learning. *Metacognition and Learning, 1*, 3–14.