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Factor Structure of Mathematics Learning Proactiveness Among Mathematics Students

Christine Joy C. Ramos[1*], Nikka C. Castañeda[2]
[1,2] Isabela State University Roxas-Campus
* e-mail: christineramos528@gmail.com

Abstract

Proactive learning is crucial for student success in mathematics and for fostering independent learning. This review explores mathematics learning proactiveness as a key factor influencing achievement, highlighting the interconnected roles of motivation**,** self-regulated learning (SRL), and academic engagement. Using a qualitative literature review of peer-reviewed studies published between 2015 and 2025, thematic synthesis identified essential concepts and findings. Results indicate that intrinsic motivation, mathematics self-efficacy, and positive attitudes promote persistence and deeper engagement. SRL components such as goal setting, effective learning strategies, reflection, resource utilization, and time management equip learners to take initiative and adapt to challenges. Academic engagement—including behavioral, cognitive, and affective dimensions—translates these internal processes into sustained learning actions. The evidence shows that proactive learning is not innate but can be cultivated through supportive, autonomy-enhancing environments. This review provides implications for educators and curriculum designers to nurture autonomy, resilience, and long-term achievement in mathematics..

Keywords : *Mathematics learning proactiveness; self-regulated learning;*

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INTRODUCTION

Academic success in mathematics depends not only on cognitive ability but also on students' willingness and ability to take initiative in their learning. Mathematics learning proactiveness—defined as a learner's capacity to anticipate challenges, regulate their learning behavior, and persist in goal-directed tasks—plays a central role in promoting student achievement and engagement in math education. Existing studies highlight that proactive learners, particularly those who engage in self-regulated learning (SRL), are more likely to perform well academically. According to (Greene, J. A., & Yu, 2021), SRL involves planning, monitoring, and evaluating one's learning strategies, and is deeply linked to proactive learning behaviors. Similarly, Usher, E. L., & Pajares, (2016) and pajares, F., & Miller, 1994) emphasize that academic self-efficacy and motivational factors significantly shape students' engagement and persistence, especially in challenging subjects like mathematics. The importance of these studies lies in their contribution to understanding how proactive learning behaviors and self-regulation mechanisms influence academic success.

Therefore, this article review aims to examine and synthesize recent findings that explore the key dimensions, influences, and outcomes of mathematics learning proactiveness. It focuses on how cognitive, motivational, and emotional factors contribute to students' proactive engagement in mathematics, drawing insights from empirical studies. Ultimately, the goal is to inform educators, curriculum developers, and policymakers on how to support students in becoming more self-directed, motivated, and resilient mathematics learners.

METHODS

This study used a qualitative literature review method to explore the concept of mathematics learning proactiveness. Peer-reviewed articles published between 2015 and 2025 were collected from Scopus, Web of Science, and Google Scholar. Keywords such as mathematics learning proactiveness, self-regulated learning, and student engagement guided the search. Thematic synthesis was applied to identify key concepts, theoretical models, and research gaps. Inclusion criteria focused on empirical studies and reviews related to proactive learning behaviors in mathematics education.

FINDING AND DISCUSSIONS

1. MOTIVATION IN LEARNING

Intrinsic Motivation

Intrinsic motivation, defined as the internal desire to engage in learning for its own sake, plays a foundational role in students’ mathematical engagement. When students find mathematics inherently enjoyable and meaningful, they are more likely to adopt deep learning strategies and sustain attention during complex problem-solving. This type of motivation fosters curiosity, persistence, and a willingness to explore new concepts, often without the need for external incentives. Schukajlow, S., & Rakoczy, (2016) found that autonomy-supportive tasks significantly enhanced intrinsic interest and performance in mathematics. Similarly, Linnenbrink-Garcia et al. (2018) showed that academic enjoyment—a key component of intrinsic motivation—positively correlated with higher self-regulated learning and achievement in mathematics. Intrinsic motivation also complements and strengthens other motivational dimensions such as self-efficacy and positive attitudes toward mathematics, making it a central driver in sustained academic effort.

Extrinsic Motivation

Extrinsic motivation arises when students engage in mathematical tasks in response to external rewards such as grades, praise, or recognition. While often viewed as less robust than intrinsic motivation, extrinsic motivation can still play a powerful role—particularly in initiating engagement or sustaining effort when intrinsic interest is lacking. Deci et al. (2017) demonstrated that performance-based rewards can enhance motivation and outcomes, particularly when combined with intrinsic goal-setting. Likewise, Fang et al., (2018) found that performance-approach goals predicted higher mathematics achievement when teachers provided structured, competence-based feedback. These findings suggest that extrinsic motivators, when properly aligned with students’ goals and supported by feedback, can complement and even stimulate intrinsic motivation, reinforcing self-efficacy and effort regulation.

Self-Efficacy in Mathematics

Mathematics self-efficacy—students' belief in their ability to succeed in math tasks—is a crucial dimension of motivation in learning. Learners with high self-efficacy are more confident in tackling difficult problems, more resilient in the face of setbacks, and more inclined to adopt effective learning strategies. These beliefs shape motivation by influencing goal-setting, persistence, and willingness to engage in challenging tasks. Usher, E. L., & Pajares, (2016) and Pajares (2016) found that self-efficacy strongly predicted a deep approach to learning mathematics, surpassing other motivational and cognitive predictors. Similarly, Chemers et al. (2017) emphasized that self-efficacy is a more powerful predictor of math performance than anxiety or prior achievement, underscoring its centrality in shaping effort and outcomes. When students believe they are capable, they are more likely to be intrinsically motivated, persist through difficulties, and hold more positive attitudes toward mathematics.

Persistence and Effort

Persistence and sustained effort represent the behavioral enactment of motivation, particularly critical in mathematics where tasks often require prolonged concentration and iterative problem-solving. Students who regulate their effort effectively are more likely to endure challenges, manage setbacks, and reach higher levels of conceptual understanding. Tang, X., Wang, M. T., Guo, J., & Salmela-Aro, (2020) observed that learners who displayed persistence despite initial failures demonstrated stronger conceptual mastery in mathematics. Barroso et al., (2020) further showed that perseverance could mitigate the negative effects of math anxiety, leading to improved resilience and problem-solving capacity. Persistence is thus closely tied to self-efficacy and attitudes—students who believe in their capabilities and enjoy math are more willing to exert effort, and this effort in turn reinforces their motivation and competence beliefs.

Attitudes Toward Mathematics

Students' attitudes toward mathematics—shaped by beliefs, emotions, and previous experiences—are a powerful influence on motivation. Positive attitudes promote confidence, reduce avoidance behaviors, and increase willingness to engage with mathematical tasks. These affective dispositions often reflect and reinforce intrinsic motivation, effort, and self-efficacy. Erturan et al., n.d. confirmed that learners with more favorable attitudes toward mathematics showed greater confidence and higher achievement. Similarly, Li and Bates (2018) found that supportive classroom environments fostering positive attitudes lead to enhanced cognitive and emotional engagement in mathematics. These attitudes not only motivate students to perform but also create a positive feedback loop: success boosts confidence, which reinforces effort and deepens engagement.

2. SELF-REGULATED LEARNING (SRL)

Goal Setting and Planning

Goal setting and planning serve as foundational processes in self-regulated learning, enabling students to establish intentional pathways toward mastering mathematical concepts. By setting specific, attainable goals, learners develop a sense of direction and purpose, which motivates the use of strategic planning and promotes persistence in problem-solving. These processes activate metacognitive engagement, allowing students to anticipate challenges and allocate time and resources effectively. Moos, D. C., & Pitton, (2014) found that students who engaged in goal-setting interventions exhibited higher math achievement due to enhanced focus and self-direction. Similarly, Bannert et al., 2015) demonstrated that planning behaviors increased students' awareness of task demands and improved performance in complex mathematical tasks. When goal setting is integrated with other self-regulatory dimensions—such as strategy use and reflection—it becomes a dynamic driver of sustained academic effort.

Learning Strategies

Learning strategies—such as summarizing, elaboration, and self-questioning—are instrumental in fostering students' active engagement with mathematical content. These strategies allow learners to process information more deeply and develop independent problem-solving skills. When used consistently, they support cognitive organization and aid retention, especially when learners are faced with novel or abstract mathematical problems. Dent et al., (2016) conducted a meta-analysis showing that the use of cognitive and metacognitive strategies significantly predicted students' self-regulated learning behaviors and academic success. Similarly, (Greene et al., 2015) emphasized that students who actively employed deep-level strategies during math learning exhibited better task persistence, conceptual understanding, and motivation. These strategies interact closely with other SRL processes such as planning and time management, reinforcing a cycle of intentional, reflective learning.

Self-Reflection

Self-reflection is a critical self-regulatory process through which learners monitor and evaluate their performance, fostering adaptive responses to mathematical challenges. Reflective learners are more likely to adjust their strategies based on what worked or failed, enhancing metacognitive awareness and promoting academic resilience. This evaluative process contributes to a growth mindset, encouraging students to view mistakes as learning opportunities rather than failures. Panadero, E., Jonsson, A., & Botella, 2017) emphasized that reflective practices increase problem-solving efficiency and reduce the use of ineffective trial-and-error strategies. Furthermore, (Michalsky, T., & Schechter, (2018) found that students who engaged in structured self-reflection demonstrated improved metacognitive knowledge and math performance. Reflection also bridges other dimensions of SRL—such as strategy use and planning—by enabling continuous improvement across learning cycles.

Resource Utilization

Resource utilization involves students' proactive engagement with a variety of learning aids—ranging from digital tools and feedback to collaborative learning and instructional materials—thereby supporting autonomy and reducing reliance on teacher input. Students who actively seek and apply these resources are often better at clarifying misunderstandings, deepening conceptual understanding, and enhancing problem-solving efficiency in mathematics. (Green, J. A., Bolick, C. M., McDonald, J., & Okello, 2019) highlighted that frequent use of digital platforms and teacher feedback predicted higher engagement and accuracy in mathematical tasks. Xu, B., Chen, N. S., & Chen, (2020) similarly demonstrated that strategic use of online resources supported students' self-directed learning and contributed to greater achievement. Resource utilization also complements dimensions like planning and reflection by equipping learners with tools to execute and evaluate their learning strategies.

Time Management

Time management is a pivotal self-regulation skill that affects students' ability to meet deadlines, prepare adequately for assessments, and sustain effort over time in mathematics. Learners who effectively allocate time to studying and avoid procrastination often exhibit higher achievement and lower anxiety. Kitsantas, A., Cheema, J. R., & Ware, (2017) found that students who developed time management plans performed better in mathematics due to improved focus and reduced last-minute cramming. Wolters, C. A., & Brady (2020) also reported that students with higher perceived control over their time were more likely to use strategic learning approaches, which led to better academic performance. Time management interacts with other SRL dimensions like goal setting and learning strategies by ensuring that planned activities are executed efficiently and reflectively.

3. ACADEMIC ENGAGEMENT

Behavioral Engagement

Behavioral engagement refers to students' observable involvement in academic activities, such as attending class, participating in discussions, completing tasks, and demonstrating sustained effort in learning mathematics. This form of engagement is a visible indicator of motivation and underpins the development of deeper learning dispositions. Students who are behaviorally engaged tend to invest time and energy in completing math tasks, which also supports the activation of cognitive and emotional engagement. Reeve, J., & Tseng, (2011) demonstrated that when students are provided with autonomy-supportive environments, their behavioral engagement—measured through persistence and participation—increases significantly. More recently, Liu, W., Tian, L., Wang, Z., & Huebner, (2022) found that behavioral engagement is positively associated with improved problem-solving performance and consistency in mathematical tasks, especially when students feel a sense of structure and support. Behavioral engagement acts as a gateway through which affective and cognitive engagement are sustained over time.

Cognitive Engagement

Cognitive engagement entails students' mental investment, strategic thinking, and willingness to put forth sustained intellectual effort to understand and apply mathematical concepts. It builds upon behavioral engagement by translating participation into deeper processing and higher-order thinking. When learners are cognitively engaged, they tend to use elaborative strategies, self-monitoring, and self-explanation—practices that promote academic self-regulation and mastery of complex content. Greene et al. (2017) found that cognitive engagement predicted academic success in mathematics by mediating the relationship between motivation and performance. Jang et al., (2016) further noted that cognitively engaged students are more likely to pursue mastery goals and demonstrate persistence in solving challenging math tasks. Cognitive engagement therefore not only enhances comprehension but also strengthens persistence and motivation, aligning closely with both affective and behavioral components of engagement.

Affective Engagement

Affective engagement reflects students' emotional responses to learning mathematics, such as interest, enjoyment, pride, anxiety, or boredom. These emotions significantly shape learners' willingness to participate and persist in academic tasks. Positive affective experiences can reinforce behavioral and cognitive engagement, whereas negative emotions like fear or frustration may hinder students' motivation and strategic involvement. (Pekrun, R., Lichtenfeld, S., Marsh, H. W., Murayama, K., & Goetz, 2017) showed that students who experience enjoyment and pride in their math classes tend to display more sustained effort and better academic performance. In contrast, Wang, Z., Lukowski, S. L., Hart, S. A., & Willcutt, (2021) emphasized that negative emotions, particularly math anxiety and boredom, are associated with withdrawal and reduced engagement. Thus, affective engagement interacts closely with cognitive investment and behavioral participation, creating either upward or downward cycles of learning motivation.

Persistence and Problem-Solving Approach

Persistence—the ability to sustain effort over time despite challenges—is a core indicator of academic engagement, particularly in mathematics where tasks often require trial, error, and iterative thinking. When students are emotionally invested and cognitively engaged, they are more likely to persevere through complex problems using adaptive strategies. A problem-solving approach that values effort and learning over quick correctness enhances resilience and aligns with mastery-oriented motivation. Datu et al., (2018) reported that grit and perseverance were positively associated with mathematics achievement, especially under pressure. Similarly, Tang, X., Wang, M. T., Guo, J., & Salmela-Aro, (2020) found that students who demonstrated persistence and embraced a growth mindset approached mathematical challenges with higher confidence and greater adaptability. Persistence is thus a culmination of affective, behavioral, and cognitive engagement, reinforcing a holistic commitment to learning.

CONCLUSIONS

This review highlights mathematics learning proactiveness as a vital factor in student achievement, driven by motivation, self-regulation, and engagement. Intrinsic motivation, self-efficacy, and positive attitudes empower students to persist through challenges, while self-regulated learning strategies like planning, reflection, and time management support deeper understanding. Academic engagement—behavioral, cognitive, and emotional—translates these internal processes into consistent learning effort. The evidence suggests that proactive learning in mathematics is not innate but can be cultivated. Educators and policymakers play a key role in creating environments that promote autonomy, strategic thinking, and resilience. Supporting students in becoming proactive learners is essential for long-term success in mathematics and beyond.

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