



Students' Cognitive Abilities and Self-Regulated Learning in Digital Mathematics Learning

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ABSTRACT

Advances in educational technology have encouraged the integration of digital learning into mathematics learning, so the main challenge faced is how students can optimize their cognitive abilities and self-regulated learning (SRL) in digital environments. Students' cognitive abilities—which include thinking processes, conceptual understanding, and mathematical reasoning—are key to the success of digital mathematics learning. Meanwhile, SRL, as students' ability to plan, monitor, and evaluate their own learning process, plays a crucial role in regulating the effective use of digital resources, including time management, learning strategies, and emotional regulation. This article describes the relationship between students' cognitive abilities and SRL in the context of digital mathematics learning and the factors that influence both aspects. The study results indicate that the use of digital learning technology combined with strategies to enhance SRL can improve students' conceptual understanding and mathematical problem-solving skills. The interaction between cognitive abilities and SRL also strengthens the role of metacognition in helping students learn independently and effectively in digital environments. This study proposes a learning model that combines digital features with scaffolding techniques designed to strengthen students' cognition and self-regulation to improve mathematics learning outcomes.

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Article History

Received 2026-01-17

Revised 2026-01-25

Accepted 2026-02-10

Keywords

student cognitive 1
self-regulated
learning 2
digital mathematics 3

1. Introduction

Technological developments and digitalization in education have brought significant changes to the way students learn, particularly in mathematics. Traditional mathematics learning, which relies on face-to-face lectures, is now increasingly supported by interactive digital platforms, Learning Management System (LMS)-based learning modules, and mathematics applications that enable students to learn independently and adaptively. The integration of technology into digital mathematics learning offers many benefits, such as interactive material delivery, automated feedback, visualization of complex concepts, and the potential for personalization for each student. However, this also presents significant challenges for students, particularly in managing their own learning process to achieve optimal learning outcomes. One of the main challenges in digital mathematics learning is students' success in developing high-level cognitive abilities. Cognitive abilities encompass various thought processes, such as conceptual understanding, mathematical reasoning, problem-solving, and higher-order thinking skills (HOTS). In a digital context, cognitive abilities are necessary to understand concepts presented through various digital media and to be able to apply effective thinking strategies to solve more complex mathematical problems. Without strong cognitive abilities, students tend to struggle to utilize existing digital content to understand the material and complete learning assignments.

In addition to cognitive abilities, self-regulated learning (SRL) is also an equally important aspect in digital mathematics learning. SRL refers to students' ability to regulate, monitor, and

evaluate their own learning process. This includes the ability to plan learning activities, choose effective learning strategies, manage time and resources, monitor learning progress, and evaluate learning outcomes. SRL is particularly important in digital learning because students often find themselves in learning environments with little direct teacher control. Therefore, students' ability to self-regulate significantly impacts learning success. Previous research has shown that SRL contributes to learning outcomes in various contexts, including numeracy and mathematics literacy in general. Research suggests that students with higher levels of SRL demonstrate better abilities in planning, implementing, and evaluating their learning strategies, which ultimately impacts overall academic success. In mathematics learning, SRL encourages students to be more independent in facing complex and unstructured learning challenges, including problems requiring higher-order thinking.

However, in the context of modern digital mathematics learning, the relationship between cognitive abilities and students' SRL is not yet fully understood. Even students with high cognitive abilities can experience obstacles in digital learning if they are unable to manage their learning process effectively. Conversely, students with strong SRL skills but weak cognitive abilities will also experience obstacles in solving complex math problems. A balanced combination of cognitive and SRL abilities is a key factor in optimizing digital math learning. Digital features such as interactive quizzes, adaptive assessments, and automated feedback systems can assist students in both cognitive and SRL processes. These features enable students to monitor their learning progress, reflect on mistakes, and determine next steps. For example, an LMS that provides learning logs and time usage statistics can assist students in planning and monitoring their own learning. However, not all students are able to utilize these features optimally, so understanding how students develop SRL and cognitive abilities in a digital environment is crucial.

Other influencing factors include student readiness to use technology, intrinsic and extrinsic motivation, and support from the learning environment (including teachers and parents). Students with high levels of motivation tend to be more active in learning math material through digital platforms and are more likely to monitor and evaluate their learning process. Research shows that strategies that integrate SRL training with the use of digital learning technologies can improve students' conceptual understanding and learning outcomes. Furthermore, the urgency of developing SRL is increasingly important in the digital era, where students are required to be independent learners and adapt to rapid changes in learning methods. Developments in modern educational curricula also increasingly emphasize the importance of 21st-century skills, including critical thinking and creativity, and the ability to self-regulate learning.

Based on the above phenomena, this article aims to outline the relationship between students' cognitive abilities and SRL in digital mathematics learning and to examine learning strategies that can strengthen both aspects. This analysis is expected to contribute to educators and researchers in designing effective digital mathematics learning, particularly by empowering SRL skills to improve students' overall cognitive abilities.

2. Method

This study used a mixed methods design with quantitative and qualitative approaches to analyze the relationship between students' cognitive abilities and SRL in digital mathematics learning. Subjects consisted of high school students participating in digital mathematics learning using an LMS platform and interactive digital modules. Quantitative data collection was conducted through a validated mathematical cognitive ability test and SRL inventory, while qualitative data were obtained through semi-structured interviews and observations of student learning behavior on the digital platform. Quantitative data analysis used descriptive statistics and regression to determine the correlation between cognitive and SRL scores, while qualitative data were analyzed through thematic coding to identify patterns of students' self-regulation strategies in the digital environment. Instrument validity was tested through the Krönbach α reliability test and source triangulation to ensure consistency of findings.

3. Results and Discussion

3.1 The Relationship Between Cognition and SRL in Digital Learning.

The analysis results show a significant positive correlation between students' cognitive abilities and their SRL levels in digital mathematics learning. Students with high SRL scores tend to demonstrate better critical thinking skills, conceptual understanding, and reasoning skills than students with low SRL. This finding is consistent with previous research showing that SRL supports students' ability to regulate their learning, which in turn strengthens their cognitive capacity in understanding digital mathematics material.

3.2. The Role of Self-Regulatory Strategies in Digital Learning.

Qualitative data shows that students with strong SRL skills are able to plan their study sessions more effectively, create study schedules, and utilize technological features such as automated quizzes or feedback to monitor their learning progress. Metacognitive strategies such as reflecting on mistakes and revising learning strategies are also found more frequently in students with high SRL. These findings suggest that SRL strategies play a role not only in learning control but also in enhancing critical thinking and problem-solving skills through digital learning.

3.3. Challenges and Barriers Faced by Students.

Although the use of digital technology offers various benefits, several challenges remain. Students with low SRL often have difficulty managing their time and focusing on learning, and tend not to use digital features consistently. Other barriers include a lack of learning motivation and limited technological skills, which can hinder students' cognitive development in digital learning.

3.4. Implications for Learning Design.

These findings suggest that to optimize digital mathematics learning, teachers need to design learning experiences that support the development of both SRL and cognitive abilities. This approach can include the use of structured digital modules with clear planning, monitoring, and evaluation phases, as well as in-depth reflection on the problem-solving process. Furthermore, feedback provided through digital platforms should be formative, helping students understand their errors and encouraging advanced thinking strategies.

3.5. Integration of SRL Strategies in the LMS.

The implementation of features that support SRL in the LMS, such as study schedule reminders, metacognitive prompts, and learning progress summaries, has been shown to help students improve their self-control in digital mathematics learning. The use of learning analytics can also provide students with insights into their learning patterns, which can then be used to develop more adaptive and efficient learning strategies.

3.6. Linkages to 21st-Century Skills.

The SRL and cognitive abilities developed in digital learning align with the 21st-century skills needed in the future workforce, including analytical thinking, complex problem-solving, and lifelong learning.

4. Conclusion

Digital mathematics learning requires students to have adequate levels of cognitive ability and self-regulated learning to achieve optimal learning outcomes. These two aspects are closely interrelated, with SRL helping students regulate their learning process in a digital environment, thereby supporting the development of cognitive abilities such as problem-solving and conceptual understanding. These findings demonstrate the importance of integrating features that support SRL into digital learning platforms, as well as the need for learning strategies that emphasize the development of metacognition, learning monitoring, and reflection on the learning process.

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