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AI-Supported Grade 10 Mathematics Teaching for Developing Students' Self-Regulated Learning Competence in Vietnam: The Case of Tuyen Quang Province

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Abstract---This study examines the implementation of artificial intelligence-supported Grade 10 mathematics teaching and its effectiveness in developing students' self-regulated learning competence in Tuyen Quang Province, Vietnam. A mixed-methods approach was employed, combining quantitative data from 198 students with qualitative observations and interviews. The results indicate that students' self-regulated learning competence was initially at a moderate level, with stronger performance in motivational and behavioral aspects than in cognitive strategies. After the intervention, significant improvements were observed in self-monitoring, reflection, learning motivation, and problem-solving autonomy. Statistical analysis also revealed gender differences, with female students outperforming male students in certain dimensions of self-regulated learning. In addition, teachers demonstrated high awareness of the importance of self-regulated learning but limited use of artificial intelligence in instructional practices. The findings suggest that artificial intelligence, when used as a learning companion with scaffolding and guided questioning, can effectively enhance students' autonomy and engagement. The study provides empirical evidence from a local Vietnamese context and offers practical implications for integrating artificial intelligence into mathematics education.

Keywords---Artificial Intelligence, Mathematics Education, Self-Regulated Learning, Grade 10, Learning Analytics, Vietnam.

Introduction

In the context of global digital transformation, the integration of artificial intelligence into education has become a significant trend, reshaping teaching and learning practices across disciplines. In Vietnam, the ongoing implementation of competency-based education emphasizes the development of learners' autonomy, critical thinking, and problem-solving abilities. Among these competencies, self-regulated learning plays a central role, particularly in mathematics education, where students are required to engage actively in abstract reasoning and

independent problem-solving processes. Self-regulated learning enables learners to plan, monitor, and evaluate their own learning, thereby enhancing both academic achievement and lifelong learning capacity (Dignath & Veenman, 2021; Efklides, 2011).

However, despite its importance, the development of self-regulated learning competence among high school students remains limited in many traditional classroom settings. Mathematics instruction in upper secondary schools in Vietnam is often characterized by teacher-centered approaches, where students passively receive knowledge rather than actively constructing it. This situation restricts opportunities for students to develop metacognitive awareness and learning autonomy, which are essential components of self-regulated learning (Dignath & Büttner, 2018).

Recent advances in artificial intelligence technologies offer promising solutions to address these challenges. Artificial intelligence tools, such as intelligent tutoring systems, chatbots, and learning analytics platforms, provide personalized learning experiences, adaptive instruction, and real-time feedback. These features allow learners to engage in more flexible and individualized learning processes, supporting the development of self-regulated learning strategies (Bühler et al., 2025). In particular, generative artificial intelligence tools have demonstrated the potential to assist students in problem-solving, provide explanations, and scaffold learning processes, thereby enhancing both cognitive and metacognitive engagement (Steinert et al., 2023).

Furthermore, research indicates that artificial intelligence can play a critical role in fostering self-regulated learning by supporting goal setting, self-monitoring, and reflection. Learning analytics systems, for example, can capture students' learning behaviors and provide feedback that promotes awareness of their learning strategies (Du et al., 2023). Meta-analytical studies have also confirmed that artificial intelligence-based learning environments can positively influence learner autonomy and self-regulated learning competence when appropriately implemented (Achuthan, 2025; De Mooij et al., 2025).

Nevertheless, the integration of artificial intelligence into education is not without challenges. Some studies have raised concerns about students' overreliance on artificial intelligence tools, which may lead to reduced cognitive effort and diminished metacognitive engagement, a phenomenon referred to as "metacognitive laziness" (Fan et al., 2025). Therefore, it is essential to design pedagogical approaches that leverage the advantages of artificial intelligence while maintaining students' active participation and critical thinking.

Despite the growing body of international research, empirical studies examining the application of artificial intelligence in mathematics teaching at the high school level in Vietnam remain scarce, particularly in rural and mountainous areas such as Tuyen Quang Province. There is a need for context-specific research that explores how artificial intelligence can be effectively integrated into classroom practices to enhance students' self-regulated learning competence.

In response to this gap, the present study investigates the implementation of artificial intelligence-supported Grade 10 mathematics teaching in upper secondary schools in Tuyen Quang Province, to propose an instructional approach that integrates artificial intelligence tools and examines its contribution to the development of students' self-regulated learning competence (Hornberger et al., 2023).

Literature Review

Self-Regulated Learning in Mathematics

Self-regulated learning has been widely recognized as a fundamental competence that enables learners to take control of their own learning processes. It refers to learners' ability to plan, monitor, and evaluate their cognitive, motivational, and behavioral activities to achieve learning goals (Dignath & Veenman, 2021). In mathematics education, self-regulated learning is particularly important due to the abstract nature of mathematical concepts and the need for independent problem-solving.

Self-regulated learning is typically conceptualized as comprising three interrelated components: cognitive, metacognitive, and motivational. Cognitive strategies involve processes such as rehearsal, elaboration, and problem-solving, which are essential for understanding mathematical concepts. Metacognitive strategies include planning, monitoring, and self-evaluation, enabling students to regulate their thinking and adapt their learning strategies when necessary. Motivational factors, such as self-efficacy and intrinsic interest, influence students' persistence and engagement in mathematical tasks (Efklides, 2011).

In mathematics classrooms, the development of self-regulated learning competence allows students to approach problems systematically, reflect on their errors, and refine their strategies. Teachers play a crucial role in fostering this competence by designing learning environments that encourage autonomy, reflection, and strategic thinking

(Dignath & Büttner, 2018). Therefore, promoting self-regulated learning is essential for improving students' mathematical understanding and supporting lifelong learning.

Artificial Intelligence in Mathematics Education

Artificial intelligence has become an increasingly influential technology in education, offering new possibilities for enhancing teaching and learning processes. In mathematics education, artificial intelligence is applied through various tools, including intelligent tutoring systems, adaptive learning platforms, and conversational agents such as chatbots. These technologies enable personalized instruction, automated feedback, and real-time analysis of students' learning behaviors (Bray & Tangney, 2017).

One of the most significant advantages of artificial intelligence is its capacity to personalize learning experiences. By analyzing students' performance data, artificial intelligence systems can identify individual learning needs and provide tailored instructional content. This personalization is particularly beneficial in mathematics, where students often exhibit diverse levels of understanding and learning pace (Bühler et al., 2025).

Additionally, artificial intelligence tools provide immediate feedback, allowing students to identify and correct errors during the learning process. This feature helps reduce misconceptions and supports continuous learning. Intelligent tutoring systems, for example, can guide students through step-by-step problem-solving processes, thereby enhancing conceptual understanding and procedural fluency.

Furthermore, learning analytics enabled by artificial intelligence can offer valuable insights into students' learning patterns. These insights allow teachers to better understand students' difficulties and adapt their instructional strategies accordingly. As a result, artificial intelligence not only supports students' learning but also enhances teachers' instructional effectiveness.

Artificial Intelligence and Self-Regulated Learning

The integration of artificial intelligence into education has significant implications for the development of self-regulated learning. Artificial intelligence tools can support key self-regulation processes, including goal setting, self-monitoring, and reflection. For instance, intelligent systems can assist students in defining learning objectives, tracking their progress, and receiving feedback on their performance, thereby fostering greater learning autonomy. Learning analytics technologies play a particularly important role in this context. By capturing and analyzing students' interaction data, these systems can provide insights into learning behaviors and strategies, helping students become more aware of their learning processes (Du et al., 2023). This awareness is a critical component of metacognitive regulation.

Moreover, artificial intelligence can facilitate scaffolding by providing hints, prompts, and guided explanations. Such support encourages students to engage in deeper thinking and reflection rather than relying solely on direct answers. Studies have shown that well-designed artificial intelligence systems can enhance students' metacognitive engagement and promote effective self-regulation (De Mooij et al., 2025).

However, the use of artificial intelligence also presents potential challenges. Overreliance on artificial intelligence tools may lead to reduced cognitive effort and diminished metacognitive engagement, a phenomenon referred to as "metacognitive laziness" (Fan et al., 2025). Therefore, it is important to ensure that artificial intelligence is used as a supportive tool rather than a substitute for active learning.

Overall, when appropriately integrated into instructional practices, artificial intelligence can significantly enhance students' self-regulated learning competence by supporting cognitive, metacognitive, and motivational processes (Achuthan, 2025).

Research Gap

Despite the growing body of international research on artificial intelligence and self-regulated learning, several gaps remain, particularly in the context of mathematics education in Vietnam.

First, there is a lack of empirical studies examining the effectiveness of artificial intelligence-supported instruction in Vietnamese high school settings. Most existing studies are either theoretical or limited to small-scale pilot implementations, making it difficult to generalize findings.

Second, there is currently no well-defined instructional model integrating artificial intelligence into Grade 10 mathematics teaching with a specific focus on developing self-regulated learning competence. Existing research tends to focus on general applications of technology rather than subject-specific pedagogical models.

Third, there is a notable absence of research conducted in local contexts such as Tuyen Quang Province. Educational conditions in such regions differ significantly from urban areas in terms of infrastructure, access to technology, and students' learning habits. Therefore, context-specific studies are necessary to provide practical and applicable insights.

These gaps highlight the need for research that not only examines the impact of artificial intelligence on self-regulated learning but also proposes a concrete instructional model tailored to the teaching of Grade 10 mathematics in specific educational contexts (Anh & Duong, 2023).

Methodology

Research Design

This study employed a mixed-methods research design combining both quantitative and qualitative approaches in order to provide a comprehensive understanding of the effectiveness of artificial intelligence-supported mathematics teaching. The quantitative component focused on measuring students' self-regulated learning competence through survey data, while the qualitative component aimed to explore students' learning behaviors and experiences in more depth.

In addition, the study adopted a quasi-experimental approach through pedagogical intervention. This approach allowed the researchers to examine the impact of integrating artificial intelligence tools into Grade 10 mathematics teaching on students' self-regulated learning competence. The design included a preliminary survey to assess the current situation, followed by the implementation of AI-supported instructional activities and subsequent evaluation.

Participants

The participants of the study consisted of 198 Grade 10 students from Dong Tho High School in Tuyen Quang Province. Among them, 92 were male students, and 106 were female students. This sample provided a representative overview of students' learning characteristics at the upper secondary level in a local educational context.

In addition to students, mathematics teachers at the school were also involved in the study. These teachers participated in the survey and provided insights into the current practices of mathematics teaching and the use of artificial intelligence in the classroom. Their perspectives contributed to a more comprehensive understanding of both teaching practices and challenges in implementing AI-supported instruction.

Instruments

Data collection was conducted using multiple instruments to ensure the reliability and validity of the findings.

First, a structured questionnaire based on a five-point Likert scale was administered to students. The questionnaire focused on three main criteria (C1, C2, and C3), which reflected students' perceptions, learning behaviors, and levels of self-regulated learning competence.

Second, statistical analysis was conducted using IBM SPSS Statistics software. This tool was used to process and analyze the collected data, allowing for the calculation of descriptive and inferential statistics.

Third, an Independent Samples T-test was employed to examine differences in self-regulated learning competence between male and female students. This analysis helped identify whether gender-related differences were statistically significant.

Finally, qualitative data were collected through classroom observations and informal interviews with both students and teachers. These methods provided additional insights into students' engagement, learning strategies, and the effectiveness of AI-supported activities in the learning process.

Procedure

The research was conducted in several stages to ensure a systematic and coherent process.

In the first stage, a preliminary survey was carried out to investigate the current situation of mathematics teaching and students' self-regulated learning competence. The survey results provided a baseline for subsequent intervention.

In the second stage, artificial intelligence-supported instructional activities were designed based on the principles of personalized learning, scaffolding, and self-regulation. These activities incorporated tools such as AI chatbots and digital learning platforms to support students' independent learning.

In the third stage, pedagogical experiments were implemented in Grade 10 mathematics classes. Students participated in AI-supported learning activities, which aimed to enhance their ability to plan, monitor, and evaluate their learning processes.

In the final stage, data were collected and analyzed to evaluate the effectiveness of the intervention. Both quantitative and qualitative data were used to provide a comprehensive assessment of students' self-regulated learning development.

Data Analysis

The collected data were analyzed using both descriptive and inferential statistical methods.

Descriptive statistics, including mean (M) and standard deviation (SD), were calculated to summarize students' responses and identify general trends in self-regulated learning competence.

Inferential analysis was conducted using Independent Samples T-tests to examine differences between groups, particularly in relation to gender. A significance level of $\alpha = 0.05$ was adopted. Results with Sig. values lower than 0.05 were considered statistically significant, indicating meaningful differences between groups.

The combination of quantitative statistical analysis and qualitative interpretation allowed for a comprehensive evaluation of the effectiveness of artificial intelligence-supported mathematics teaching in developing students' self-regulated learning competence.

AI-Supported Mathematics Teaching Model

Design Philosophy

The design of the AI-supported mathematics teaching model in this study is grounded in the concept of artificial intelligence as an "intelligent learning companion" rather than a replacement for teachers. In this approach, artificial intelligence functions as a supportive tool that guides, prompts, and scaffolds students' thinking processes, thereby enhancing their ability to learn independently.

A key pedagogical principle applied in this model is Socratic questioning. Instead of providing direct answers, the AI system is designed to pose guiding questions that encourage students to reflect on their reasoning, identify errors, and construct their own understanding. This approach promotes deeper cognitive engagement and supports the development of critical thinking skills.

Another fundamental principle is scaffolding. The AI system provides graduated support based on students' needs, ranging from simple hints to more detailed explanations. This scaffolding mechanism helps reduce cognitive load while maintaining students' active involvement in problem-solving. Over time, the level of support is gradually reduced, enabling students to become more autonomous in their learning.

AI-Supported Learning Components

The proposed model integrates several key components of artificial intelligence to support the teaching and learning process.

First, the system includes an error detection mechanism that automatically identifies common mistakes in students' solutions. By analyzing students' responses, the system can pinpoint errors and provide targeted feedback, helping students recognize misconceptions and correct them.

Second, a feedback system is implemented to provide immediate and meaningful responses to students' work. This feedback is not limited to correctness but also includes explanations, suggestions, and guiding questions that encourage reflection and deeper understanding.

Third, adaptive learning paths are developed to personalize the learning experience. Based on students' performance and learning progress, the system recommends appropriate tasks and resources, allowing students to learn at their own pace and according to their individual needs.

Finally, learning analytics tools are used to track students' learning behaviors and engagement. These tools provide both students and teachers with valuable insights into learning patterns, enabling better monitoring and adjustment of learning strategies.

Instructional Activities

The AI-supported teaching model was implemented through a series of instructional activities designed to promote self-regulated learning in Grade 10 mathematics.

Activity 1: Algebra – Quadratic Functions

In this activity, students were required to solve problems related to quadratic functions independently. After attempting the problems, students used an AI-based system to check their solutions.

Instead of directly providing answers, the AI system offered step-by-step hints and guided explanations. When errors were detected, the system prompted students to reconsider their reasoning and identify the source of the mistake. This process encouraged students to engage in self-monitoring and reflection, which are essential components of self-regulated learning.

Through repeated interaction with the AI system, students gradually improved their ability to evaluate their own work and adjust their problem-solving strategies.

Activity 2: Geometry – Coordinate System

This activity focused on learning concepts related to the coordinate system using a combination of artificial intelligence tools and GeoGebra software.

Students explored geometric concepts by manipulating visual representations and observing changes in real time. The AI system provided prompts and suggestions to guide students' exploration, encouraging them to formulate hypotheses and test their ideas.

This activity emphasized planning and exploration, as students were required to set learning goals, experiment with different approaches, and draw conclusions based on their observations. The integration of visualization and AI support enhanced students' conceptual understanding and promoted active learning.

Activity 3: Problem Solving with Chatbot

In this activity, students interacted with an AI chatbot to solve mathematical problems. Students were encouraged to ask questions and seek guidance when encountering difficulties.

The chatbot was designed to avoid providing immediate answers. Instead, it used prompting strategies to guide students toward discovering solutions on their own. For example, the chatbot might ask leading questions, suggest alternative approaches, or highlight relevant concepts.

This approach fostered independent thinking and reduced students' reliance on direct instruction. It also supported the development of problem-solving skills and self-directed learning habits.

AI-Supported Self-Regulated Learning Model

Based on the implementation of the above activities, an integrated model of AI-supported self-regulated learning was developed.

The model can be conceptualized as a process in which artificial intelligence supports learning activities, which in turn promote self-regulated learning processes and lead to improved learning outcomes.

Specifically, artificial intelligence tools facilitate the learning process by providing personalized support, feedback, and guidance. These features enable students to engage in key self-regulation processes, including goal setting, monitoring, and reflection.

Through goal setting, students define their learning objectives and plan their learning activities. Through monitoring, they track their progress and evaluate their understanding. Through reflection, they analyze their performance and adjust their strategies accordingly.

As a result, students become more autonomous and effective learners, demonstrating improved self-regulated learning competence and enhanced mathematical understanding.

Results

Students' Self-Regulated Learning Level

Descriptive statistical analysis was conducted to examine students' self-regulated learning (SRL) competence based on three criteria (C1, C2, and C3). The results indicate that the overall SRL level of Grade 10 students was at a moderate level.

Table 1
Descriptive Statistics of Students' SRL Competence

Criteria	Description	Mean (M)	Std. Deviation (SD)
C1	Cognitive strategies	3.18	0.52
C2	Learning behaviors (self-monitoring)	3.42	0.48
C3	Motivation and engagement	3.56	0.46
Overall	Self-regulated learning competence	3.39	0.49

The results show that students demonstrated relatively higher levels in motivational and behavioral aspects (C2 and C3), while cognitive strategies (C1) remained comparatively lower. This suggests that although students were engaged in learning activities, their ability to plan, organize, and evaluate their learning processes was still developing. These findings are consistent with the observed reality in the study context, where students tended to rely on teacher guidance and had not fully developed independent learning skills.

Gender Differences

An Independent Samples T-test was conducted to examine gender differences in SRL competence. The results are presented in Table 2.

Table 2
Gender Differences in SRL Competence

Criteria	Gender	Mean (M)	SD	Sig. (p-value)
C1	Male	3.16	0.53	0.214
	Female	3.20	0.51	
C2	Male	3.35	0.49	0.032*
	Female	3.48	0.46	
C3	Male	3.49	0.47	0.018*
	Female	3.62	0.44	

(*p < 0.05)

The results indicate that there were statistically significant differences between male and female students in C2 and C3 ($p < 0.05$), with female students showing higher levels of self-monitoring and motivation. However, no significant difference was found in cognitive strategies (C1), suggesting similar levels of cognitive processing between genders.

Teachers' Perceptions

Teachers' perceptions of AI-supported teaching and self-regulated learning were analyzed based on survey and interview data.

Table 3
Teachers' Perceptions of AI and SRL

Aspect	Mean (M)	Interpretation
Awareness of SRL importance	4.12	High
Perceived role of AI in teaching	3.85	Relatively high
Actual use of AI in teaching	2.94	Moderate–low
Confidence in using AI tools	3.02	Moderate

The findings indicate that while teachers had a strong awareness of the importance of self-regulated learning and recognized the potential of artificial intelligence, their actual implementation of AI in teaching remained limited. This gap reflects challenges related to technological infrastructure, training, and pedagogical integration.

Impact of AI-Supported Teaching

The effectiveness of AI-supported teaching was evaluated by comparing students' learning behaviors before and after the intervention, based on observational and survey data.

Table 4
Changes in Students' SRL After AI Intervention

Indicator	Before (M)	After (M)	Difference
Self-monitoring	3.21	3.58	+0.37
Reflection ability	3.05	3.46	+0.41
Learning motivation	3.34	3.71	+0.37
Problem-solving autonomy	3.12	3.55	+0.43

The results demonstrate a noticeable improvement in all measured aspects of self-regulated learning after the implementation of AI-supported instructional activities. The most significant improvements were observed in students' reflection ability and problem-solving autonomy.

Qualitative observations further revealed that students became more proactive in identifying errors, exploring alternative solutions, and managing their own learning processes. AI tools played a critical role in providing immediate feedback and guiding students through reflective thinking processes.

These findings confirm that AI-supported teaching can effectively enhance students' self-regulated learning competence by promoting active engagement, autonomy, and metacognitive awareness.

Discussion

The findings of this study provide compelling evidence that artificial intelligence-supported mathematics teaching can significantly contribute to the development of students' self-regulated learning competence. The observed improvements in self-monitoring, reflection ability, learning motivation, and problem-solving autonomy indicate that AI not only enhances learning performance but also strengthens the internal processes that underpin effective self-regulated learning. These results suggest that AI-supported instructional approaches are particularly effective in promoting the cognitive, metacognitive, and motivational dimensions of self-regulated learning.

From a cognitive perspective, the integration of AI tools enabled students to engage more actively in problem-solving processes. The use of error detection mechanisms and step-by-step hints helped students identify misconceptions and refine their reasoning. This supports the development of cognitive strategies, which are essential for understanding mathematical concepts. At the same time, the application of Socratic questioning encouraged students to reflect on their thinking, evaluate their progress, and adjust their strategies accordingly. These processes are closely aligned with the core components of self-regulated learning, including planning, monitoring, and evaluation. The improvement in reflection ability observed in the results further confirms the role of AI in enhancing metacognitive awareness.

In addition, the findings highlight the important role of motivation in the development of self-regulated learning competence. The increase in students' engagement and learning motivation suggests that AI-supported learning environments can create more interactive and personalized learning experiences. Immediate feedback and adaptive learning paths appear to have enhanced students' confidence and persistence, which are critical factors for sustaining self-regulated learning processes. This aligns with theoretical perspectives emphasizing the interplay between motivation and metacognition in self-regulated learning.

The results also provide important insights into the influence of contextual factors on the development of self-regulated learning competence. The moderate baseline level of students' self-regulated learning indicates that many students initially lacked strong independent learning skills and were accustomed to teacher-centered instruction. In this context, AI-supported teaching functioned as a transitional mechanism, gradually shifting the learning process from teacher control to learner autonomy. The structured use of scaffolding and guided questioning helped students move from passive learning to more active and self-directed engagement. However, the findings also reveal that the effectiveness of AI-supported teaching is influenced by teachers' ability to integrate technology into their instructional practices. Although teachers demonstrated a high level of awareness regarding the importance of self-

regulated learning, their actual use of AI tools remained limited, reflecting challenges related to training and technological resources.

Despite the positive outcomes, several challenges were identified in the process of developing self-regulated learning competence through AI-supported teaching. One significant issue is the potential overreliance on artificial intelligence tools. While AI provides valuable support, excessive dependence on automated feedback and guidance may reduce students' cognitive effort and limit the development of independent problem-solving skills. This raises concerns about the possible emergence of superficial learning behaviors, where students rely on external assistance rather than engaging deeply with the learning material. Furthermore, the results indicate that improvements were more pronounced in motivational and behavioral aspects than in cognitive strategies, suggesting that additional instructional interventions may be required to strengthen higher-order thinking skills.

Another challenge relates to external constraints such as technological infrastructure and teacher readiness. Limited access to digital tools and insufficient professional development opportunities may hinder the effective implementation of AI-supported teaching models. These challenges highlight the need for a comprehensive approach that combines technological innovation with pedagogical support and institutional investment.

Conclusion

This study examined the implementation of artificial intelligence-supported Grade 10 mathematics teaching in Tuyen Quang Province and its role in developing students' self-regulated learning competence. The findings indicate that the integration of artificial intelligence into instructional practices can effectively enhance students' ability to plan, monitor, and evaluate their learning processes, thereby contributing to the development of key components of self-regulated learning.

The results demonstrate that AI-supported teaching environments, characterized by personalized feedback, adaptive learning pathways, and guided questioning, can promote students' cognitive engagement, metacognitive awareness, and learning motivation. In particular, the observed improvements in self-monitoring, reflection, and problem-solving autonomy highlight the potential of artificial intelligence to foster more independent and active learning behaviors. These outcomes confirm that artificial intelligence, when used as a supportive learning companion, can play a meaningful role in enhancing both learning processes and outcomes.

At the same time, the study emphasizes that the effectiveness of AI-supported teaching depends on appropriate pedagogical design and contextual adaptation. While artificial intelligence provides powerful tools for supporting learning, it does not automatically lead to improved self-regulated learning competence. Instead, its success relies on how it is integrated into instructional activities that encourage active participation, critical thinking, and reflection. The findings also reveal challenges related to students' potential overreliance on AI and teachers' limited experience in applying AI tools, suggesting the need for careful implementation and ongoing support.

This study contributes to the existing literature by providing empirical evidence from a local Vietnamese context, particularly in a non-urban educational setting. It highlights the feasibility and effectiveness of integrating artificial intelligence into mathematics teaching to support the development of self-regulated learning competence. The results also offer practical implications for educators and policymakers, emphasizing the importance of teacher training, technological infrastructure, and pedagogical innovation.

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