

Metacognitive Strategies in Education: Fostering Self-Regulated Learning across Disciplines and Learning Environments

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ABSTRACT

Effective self-regulated learning (SRL) is key to academic success, and metacognitive strategies are essential in supporting it across disciplines. This study investigates how metacognitive strategies enhance SRL in online and traditional classrooms. Employing a mixed-methods design, this study analyzed data from questionnaires, educator interviews, and classroom observations involving 300 students. The results show that the use of metacognitive strategies is positively correlated with academic success, with variation across learning environments. Educators reported inconsistent integration of strategies, underscoring the need for standardized approaches. The study recommends tailored solutions: digital tools for online self-regulation and collaborative activities for traditional settings. The study advocates for educator training programs to systematically embed metacognitive strategies into instruction. By addressing environment-specific needs, these findings offer practical paths to develop autonomous learners and improve educational outcomes.

Keywords: educational effectiveness, metacognitive strategies, online learning, self-regulated learning, traditional classroom

INTRODUCTION

In the evolving landscape of education, the ability to adapt and self-regulate learning processes stands as a cornerstone of academic success. Metacognitive strategies, which enable learners to understand and control their own cognitive activities, are increasingly recognized as vital tools for fostering SRL (Theobald, 2021). This study explores the systematic integration of metacognitive strategies within a multidisciplinary framework, encompassing computer science, business administration, biology, and English literature. It scrutinizes their efficacy in augmenting SRL outcomes across online and conventional educational environments.

Metacognitive strategies are crucial in education, as they help students take an active role in their learning, enhance comprehension, and improve academic performance (Stanton et al., 2021). They enhance students' awareness of their cognitive processes, allowing them to regulate their learning effectively. This fosters independence and self-directedness, allowing students to make informed decisions about task approaches and problem-solving methods (Kim et al., 2023). Metacognitive strategies also enhance critical thinking abilities, enabling students to critically analyze information, assess its validity and reliability, and form informed judgments. In essence, metacognitive strategies promote deeper understanding, critical thinking, and self-directed learning, making them essential for students' academic success (Rivas et al., 2022).

The rise of technology and the internet has led to a significant shift toward online learning in various educational contexts (Dhawan, 2020). Online learning offers flexibility, access to resources, and a wide range of materials, especially during the COVID-19 pandemic. However, it also presents challenges, particularly the need for SRL skills. SRL involves learners autonomously managing their learning process, setting goals, tracking progress, and adapting strategies (Yang & Stefaniak, 2023). In traditional classroom settings, students benefit from instructors and the academic environment, whereas in online learning environments, students often experience physical isolation (Quesada-Pallarès et al., 2019). Self-regulated learners set goals, reflect on past experiences, employ strategies, monitor progress, and are aware of strengths and weaknesses (Quesada-Pallarès et al., 2019). This approach typically leads to academic success. The absence of direct oversight in online learning requires students to demonstrate initiative and take responsibility for their learning. The accelerated shift to online learning has highlighted the importance of SRL skills. Students can acquire these skills, and faculty can cultivate this approach in their classrooms (Xu et al., 2022).

In the realm of educational psychology, significant attention has been given to the development of SRL skills among students (Güven & Baldan, 2020). However, there remains a conspicuous gap in the literature concerning the systematic integration of metacognitive strategies within diverse curricular frameworks, particularly when contrasting the outcomes in online and traditional classroom environments. This study seeks to address this lacuna by investigating

the efficacy of metacognitive interventions across various disciplines, aiming to discern their impact on enhancing SRL outcomes. The comparative analysis between online and traditional settings is poised to offer valuable insights into the adaptability and scalability of such strategies, potentially informing future pedagogical practices. By bridging this gap, this research endeavors to contribute to the optimization of educational methodologies, fostering an environment conducive to the cultivation of metacognitive awareness and autonomous learning.

While existing research provides a foundation for understanding metacognitive strategies in educational settings, there is a methodological gap in how these strategies are operationalized and evaluated across disciplines and learning contexts. Traditional quantitative measures may not fully encapsulate the dynamic nature of metacognitive processes, and qualitative approaches often lack the rigor to be generalizable. This study proposes a mixed-methods approach, combining quantitative data from self-report questionnaires and academic performance records with qualitative insights from interviews and classroom observations. This comprehensive methodology aims to overcome the limitations of singular approaches, offering a more holistic understanding of how metacognitive strategies influence SRL. By addressing this methodological gap, the research aspires to refine the tools available for educators and policymakers, ensuring that the integration of metacognitive strategies into curricula is both effective and measurable.

This study investigates the impact of metacognitive strategies on SRL in both online and traditional classroom environments, and examines systematic methods to improve students' metacognitive awareness and academic achievement. Thus, this study answers the following research question:

RQ: How can metacognitive strategies be systematically integrated into curricula across different disciplines to enhance SRL outcomes in online versus traditional classroom environments?

LITERATURE REVIEW

Metacognition, a term first introduced by Flavell (1976), refers to the awareness and understanding of one's own thought processes. It is often described as "thinking about thinking" (p. 231), and it involves two key components: metacognitive knowledge and metacognitive regulation. Metacognitive knowledge encompasses an individual's knowledge about their own cognitive abilities, the nature of the tasks at hand, and the strategies that might be employed to address these tasks. Metacognitive regulation refers to the regulation of cognition through planning, monitoring, and evaluating one's cognitive activities.

In educational psychology, metacognitive strategies are instrumental in fostering SRL. These strategies enable learners to plan, monitor, and evaluate their learning processes, which are essential skills for academic success. They empower

students to take control of their learning by setting goals, selecting appropriate strategies, and reflecting on their learning outcomes (Stoten, 2019).

The relevance of metacognitive strategies in education cannot be overstated. They are pivotal in helping students become more effective learners. By applying these strategies, students can improve their ability to comprehend and retain information, solve problems, and perform academically. Moreover, metacognitive strategies are not confined to a single discipline; they are applicable across various academic fields, enhancing learning in diverse educational contexts (Muhid et al., 2020).

Educational psychologists have emphasized the importance of teaching students metacognitive strategies. Research has shown that when students are taught how to use these strategies, they become more engaged and autonomous learners. This is particularly significant in today's educational landscape, where learning environments are rapidly evolving, and the ability to adapt and self-regulate is more important than ever (Ali & Razali, 2019).

Contemporary Perspectives on Metacognitive Strategies

The last five years have seen important theoretical advancements in metacognition research. Bozorgian et al. (2022) proposed a dynamic systems model that accounts for cultural variations in metacognitive development, whereas Ataş and Yıldırım (2025) emphasized the social dimensions of metacognition in collaborative learning environments. These developments complement traditional models by addressing how digitalization and globalization reshape metacognitive processes.

Recent empirical studies have demonstrated the continued importance of metacognitive strategies across educational contexts. Research has consistently demonstrated the transformative role of metacognitive strategies in STEM education. Güner and Erbay's (2021) study of eighth-grade mathematics revealed that explicit metacognitive training enhanced problem-solving accuracy by fostering systematic strategy use and logical reasoning. This aligns with findings from a parallel study (Wider & Wider, 2023), in which analysis of 37 students' problem-solving approaches revealed distinct performance patterns: high-achieving learners employed precise mathematical notation and structured planning, whereas struggling students struggled to interpret problems and identify errors. Notably, both studies identified a critical gap in metacognitive self-awareness—students frequently overestimate their ability to monitor and correct mistakes, a phenomenon also observed in broader literature (Flavell, 1976; Bozorgian et al., 2022). Collectively, these results underscore the necessity of embedding metacognitive instruction in undergraduate and secondary school STEM curricula to bridge the gap between perceived competence and actual problem-solving competence.

In the context of language learning, Teng and Wu (2024) identified four significant longitudinal mediation patterns. Overall, self-efficacy beliefs predicted the use of metacognitive strategies, which in turn predicted language-learning motivation and perceived progress in online English learning. The findings showed the potential to enhance online English learning by facilitating learners' self-efficacy beliefs, language learning motivation, and metacognitive strategies.

Metacognitive strategies in diverse learning contexts:

This section examines the application and assessment of metacognitive strategies in different learning contexts, including EFL contexts and secondary education. A study conducted by Bernardo and Mante-Estacio (2023) explored the relationship between metacognitive reading strategies and students' reading proficiency in a country that ranked last in the PISA 2018 reading assessment. A nationally representative sample of 15-year-old students participated in the study, and the data were analyzed via repeated-measures ANOVA and regression analysis. The results showed that self-reported metacognitive reading strategies accounted for a significant portion of the variation in Filipino students' English reading proficiency after controlling for socioeconomic status, sex, and number of books at home. However, the most useful reading strategies were not strongly associated with reading proficiency, suggesting that students may not be aware of which strategies are helpful in learning to read in English. The results suggest variations in students' awareness of which strategies aid in their reading comprehension and highlight the need for a better understanding of effective reading strategy instruction in Filipino students' reading classes.

An additional study by García-Pérez et al. (2021) examined higher education students' learning strategy choices, with particular focus on their adaptability across diverse learning contexts and their associations with SRL and academic achievement. Qualitative semistructured interviews with 17 Psychology and Sports Sciences students with varying self-regulatory profiles and academic performance levels were conducted. The results revealed that the students reported mainly basic learning strategies, but their cognitive and metacognitive operations were different. They also reported that students' learning strategies varied with multiple factors, with assessment activities having a significant influence. Students with low academic performance presented organizational problems and limited knowledge of learning strategies.

Another study by Cervin-Ellqvist et al. (2021) examined students' approaches to learning in higher education contexts, focusing on SRL. A questionnaire was developed to collect data from 416 engineering students, with the aim of mapping their real-world learning strategies, investigating their metacognitive awareness of the effectiveness of different strategies, and understanding why they choose certain strategies. The findings reveal a complex picture of why students sometimes use seemingly ineffective learning strategies,

which is not always due to metacognitive illusions but is often linked to attempts to regulate behavior, motivation, and/or the learning context. The study adds to existing research on students' abilities to reflect, assess, and take control of their learning, confirming that students need explicit guidance. The findings contribute to the understanding of students' learning strategies and their effectiveness in higher education.

Synthesizing studies on metacognitive strategies across diverse learning contexts underscores the nuanced relationship between these strategies and academic success. Research by Bernardo and Mante-Estacio (2023) reveals a significant correlation between metacognitive reading strategies and English reading proficiency among Filipino students, yet it also highlights a gap in students' awareness of the most effective strategies. This finding echoes that of García-Pérez et al. (2021), who reported that while students employ basic learning strategies, their cognitive and metacognitive operations vary, and their strategy choices are influenced by assessment activities and other factors. Cervin-Ellqvist et al. (2021) further elaborate on this complexity, demonstrating that students' choice of learning strategies is not solely based on metacognitive awareness but also on behavioral, motivational, and contextual regulation. Collectively, these studies illuminate the critical need for explicit instruction in metacognitive strategies to enhance SRL and academic performance across various educational settings. They advocate a deeper understanding of how students select and apply learning strategies, emphasizing the importance of tailored educational interventions that account for individual differences and contextual demands.

Metacognitive strategies in online vs. traditional classroom environments:

This section provides a comparative perspective on the use of metacognitive strategies in online learning versus traditional classroom settings. Acosta-Gonzaga and Ramirez-Arellano (2021) explored the relationships among motivation, emotions, cognition, and metacognition in blended learning contexts. It tests the hypothesis that certain factors differ between face-to-face and blended learning environments. The results show that positive emotions play a significant role in blended learning, whereas help-seeking and peer learning are relevant only within it. A positive relationship was observed between academic motivation and metacognitive strategies in face-to-face learning, whereas a negative relationship was observed in blended learning. The study concludes that emotions are relevant to students' perceived success, highlighting the importance of these factors in both learning environments.

A separate study by Maor et al. (2023) examined teachers' integration of metacognition and creativity in online lessons compared with traditional classroom instruction, prompted by the transition to online learning during the COVID-19 pandemic. The researchers analyzed 50 lesson reports (25 from each learning environment) to assess the application of creativity and metacognition in teaching.

They reported that teachers tended to use the 'debugging' metacognitive component more frequently in online lessons than in classroom settings. This suggests that online platforms may offer opportunities to promote students' learning processes and to encourage teachers to diversify their teaching methods and foster student creativity. However, the originality aspect of creativity was less emphasized in online lessons. These findings provide insights into how teaching practices adapt to different learning environments in the twenty-first century, particularly during global crises such as pandemics, and contribute to the literature on blended learning and pedagogical adaptation.

An additional study by Quesada-Pallarès et al. (2019) examined the use of motivational and SRL strategies among vocational education and training (VET) students, particularly in online learning contexts. It addresses a gap in the literature by analyzing how VET students employ these strategies on the basis of their chosen learning mode. The researchers conducted a quantitative cross-sectional study involving 577 first-year VET students who completed an online questionnaire assessing motivational and SRL strategies. Statistical analyses were used to test the hypotheses, including the validation of Pintrich's model for Catalan VET students. The findings indicate significant differences in the levels of metacognitive self-regulation and effort regulation between classroom and online students at the beginning of their VET program. However, these differences may not be solely attributed to the learning mode. The study's results offer valuable insights for VET researchers and practitioners, helping them understand students' characteristics at the program's onset and developing strategies to enhance student engagement throughout the course.

Synthesizing studies on metacognitive strategies in online and traditional classroom environments reveals a complex interplay among emotional, cognitive, and metacognitive factors that influence student learning. Acosta-Gonzaga and Ramirez-Arellano (2021) highlight the pivotal role of positive emotions in blended learning and the distinct dynamics of help-seeking and peer learning in such settings. Conversely, Maor et al. (2023) underscore the adaptability of teachers in employing 'debugging' metacognitive strategies more in online lessons, which, while promoting learning processes, may underemphasize originality in creativity. Quesada-Pallarès et al. (2019) further our understanding by demonstrating significant differences in metacognitive self-regulation and effort regulation among VET students, suggesting that these disparities are not merely a result of the learning mode but also reflect the intrinsic characteristics of the students. Collectively, these studies underscore the necessity for educators to foster an environment that balances emotional support with metacognitive and creative development, tailored to the unique demands of both online and face-to-face learning contexts. This balance is crucial for enhancing student engagement and success, particularly during transitions to online learning, as observed during the COVID-19 pandemic.

Theoretical Framework: Integrating Zimmerman’s SRL Model with Metacognitive Strategies Across Learning Environments

The theoretical framework of this study is grounded in educational psychology, emphasizing the pivotal roles of SRL and metacognitive strategies in academic achievement. SRL is conceptualized as learners’ proactive engagement in their educational journey, encompassing goal setting, progress monitoring, strategic action, and reflective practice. Central to this framework is the integration of metacognitive strategies, which are deliberate cognitive processes that guide learners in planning, monitoring, and evaluating their cognitive activities, thereby enhancing their awareness of and control over their learning trajectory.

Within this framework, Zimmerman’s model of SRL (Zimmerman, 2002), which elucidates the interplay between metacognitive processes, motivational dynamics, and behavioral actions in nurturing SRL, is incorporated. This model highlights the significance of metacognitive awareness, strategic goal orientation, self-efficacy, and reflective evaluation as cornerstones of effective learning.

Furthermore, the framework juxtaposes the application and outcomes of metacognitive strategies within online and traditional classroom contexts, recognizing that the learning environment exerts a substantial influence on the deployment of these strategies and the extent of self-regulation achieved by learners

RESEARCH METHOD

Research Design: Sequential Explanatory Mixed Methods Approach

This study employs a mixed-methods research design to investigate the impact of metacognitive strategies on SRL in both online and traditional classroom environments. The mixed-methods design for this study was chosen to ensure a comprehensive analysis of the impact of metacognitive strategies on SRL across online and traditional classroom environments. This approach combines quantitative data from self-report questionnaires with qualitative insights from interviews and classroom observations, allowing for the triangulation of data and a more nuanced understanding of the research topic. The integration of quantitative and qualitative data will occur through a sequential explanatory design, where quantitative findings will be supplemented and explained by qualitative insights during the data analysis phase. This approach enhances the validity and richness of the study's findings, providing a robust methodological framework for addressing the research questions effectively.

Data collection instruments and procedures: Triangulation of questionnaires, interviews, and observations

To ensure comprehensive data triangulation, this study employs three main instruments: self-report questionnaires, semi-structured educator interviews, and classroom observations. Each tool is selected and designed to align with the research objectives and support both quantitative and qualitative data collection. The instruments were implemented sequentially: questionnaires were distributed first, followed by interviews and classroom observations to provide contextual depth and support interpretation of the quantitative findings.

Self-Reporting Questionnaire:

The use of self-report questionnaires is pivotal in this study for several reasons. These methods enable efficient data collection from a large sample, which is essential given the 300 participants. Two established instruments were utilized:

- Metacognitive Awareness Inventory (MAI): The MAI is a validated instrument that assesses two components of metacognition: knowledge about cognition and regulation of cognition. It is chosen for its comprehensive nature and its ability to distinguish among declarative, procedural, and conditional knowledge, as well as regulatory processes such as planning, monitoring, and evaluation.

- Self-Regulated Learning Inventory (SRLI): The SRLI measures students' SRL strategies and motivational beliefs. It is selected for its alignment with Zimmerman's SRL model, which is the theoretical foundation of this study. The SRLI helps understand how students' motivational beliefs influence their use of learning strategies.

The instruments were thoughtfully adapted to align with the study's focus on both online and traditional learning environments. Key modifications included refining specific questionnaire items to address the distinct characteristics of each learning modality, ensuring relevance and precision. Additionally, supplementary items were incorporated to capture metacognitive strategies and SRL behaviors not fully encompassed by the original instruments but deemed critical to the research objectives.

To validate the adjustments, a pilot test was conducted with a cohort of 30 students to assess clarity, reliability, and cultural appropriateness. The feedback from this phase informed further refinements, culminating in a finalized questionnaire structured into five sections, each employing a 5-point Likert scale. The instrument was administered digitally and comprises key segments, including demographic profiles, metacognitive awareness, SRL, and discipline-specific scenarios.

The questionnaire was designed to evaluate multiple dimensions, such as learners' self-awareness, the efficacy of their cognitive strategies, perceived instructor support, and the alignment of course materials with metacognitive

practices. This comprehensive approach facilitates a nuanced exploration of how students perceive and employ metacognitive skills across diverse academic disciplines and learning contexts, providing robust insights into the interplay between self-regulation and instructional environments.

Educator interviews:

The semi-structured interviews with ten educators were carefully designed to yield rich qualitative data that would complement the quantitative findings from the student questionnaires. This approach was selected to allow for both focused exploration of predefined topics and the flexibility to probe deeper into emerging themes relevant to metacognitive strategy implementation.

The interview protocol was structured around several key dimensions: educators' conceptual understanding of metacognitive strategies, their practical application in teaching, the challenges encountered in different instructional settings, and their perceptions of effectiveness across disciplines. To ensure comprehensive and diverse perspectives, participant selection prioritized variation in disciplinary expertise (spanning STEM, humanities, and social sciences), teaching experience (including both early-career and senior faculty), and instructional modality (encompassing online, hybrid, and traditional classroom environments). Additionally, attention was given to cultural and institutional diversity to capture a broad spectrum of pedagogical approaches and contextual influences.

All interviews were conducted in a controlled setting, audio-recorded with consent, and subsequently transcribed verbatim while preserving participant anonymity. The interviews (45–60 minutes each) were audio-recorded, transcribed, and analyzed thematically to identify key patterns and insights. This methodological rigor ensures that the findings not only reflect a wide range of educator experiences but also provide a nuanced understanding of how metacognitive strategies are adapted across different teaching contexts.

Classroom observations:

Classroom observations serve as a critical component of the mixed-methods approach, providing direct evidence of how metacognitive strategies are implemented across different learning environments. The observation protocol was designed to yield comparative insights between online and traditional classroom settings. In online environments, the focus is on three key dimensions: (1) student–platform interactions, (2) educator facilitation of metacognitive strategies, and (3) levels of student engagement. The specific evaluation criteria included the clarity of instructional guidance, the quality of student participation in online discussions, and the effective utilization of self-monitoring tools. Four 90-minute observation sessions were conducted for each online course,

strategically scheduled at different points in the semester to capture variations in instructional delivery.

For traditional classroom observations, the focus was on the dynamics of face-to-face learning, with particular attention given to (1) the role of physical presence in strategy implementation, (2) the immediacy of feedback mechanisms, and (3) the incorporation of metacognitive prompts in live instruction. The assessment criteria focused on the frequency and nature of student-instructor interactions, the explicit integration of metacognitive strategies, and their observable effects on learning behaviors. Mirroring the online protocol, the observers conducted four complete 90-minute observations per course while deliberately varying observation times across days and weeks to account for potential scheduling-related variances.

All observations were conducted via a standardized protocol to ensure methodological consistency. Field notes were systematically organized according to predetermined criteria, facilitating subsequent cross-environment analysis. This structured yet flexible approach allowed for comprehensive documentation of metacognitive strategy implementation while maintaining the rigor required for meaningful comparison between instructional modalities.

Data Analysis:

The data analysis for this study will be conducted in two main streams: quantitative and qualitative analysis. Each stream is designed to complement the other, providing a comprehensive understanding of the research question.

Quantitative analysis: The quantitative data obtained from the self-report questionnaires were subjected to several statistical analyses via SPSS statistical software to ensure a rigorous examination of the relationship between metacognitive strategy use and academic performance.

Descriptive Statistics: This initial step involves summarizing the data to describe the sample's characteristics. Measures such as the mean, median, mode, standard deviation, and range are used to provide an overview of the data distribution and central tendencies.

Correlation Analysis: To explore the relationships between different variables, correlation coefficients are calculated. This will help in identifying whether there is a statistically significant association between the use of metacognitive strategies and students' academic performance.

Regression models: Multiple regression analysis will be employed to determine the predictive power of metacognitive strategy use for academic performance while controlling for other variables. Assumptions underlying the statistical tests, including normality assumptions for parametric tests, will be considered and met. This analysis helps in understanding the extent to which metacognitive strategies can explain variations in academic outcomes.

Effect Size Reporting: In addition to reporting significance levels, effect sizes such as Cohen's d or η^2 will be computed to elucidate the magnitude of relationships identified through statistical analyses.

This study addresses potential multicollinearity issues in multiple regression analysis by examining variance inflation factors (VIFs) to ensure predictor independence and improve interpretability. Robustness checks and sensitivity analyses will be conducted to verify the reliability and stability of the findings, including assessing consistency across different models and exploring potential outliers or influential data points.

The choice of these statistical methods aims to provide a comprehensive and objective assessment of the data, contributing to a deeper understanding of the relationship between metacognitive strategy utilization and academic performance among students.

Qualitative Analysis: The qualitative data from the educator interviews and classroom observations were subjected to thematic analysis, a method for identifying, analyzing, and reporting patterns within the data.

Coding process: The data are organized into meaningful groups through a coding process. Initial codes are generated by examining the data line-by-line, which are then clustered into potential themes.

Theme development: Themes will be reviewed and refined to ensure that they accurately represent the dataset. This iterative process involves going back and forth between the dataset and the coded extracts to develop a thematic map of the analysis.

Reporting: The final step involves a detailed description of each theme, supported by relevant quotes from participants. This provides a rich narrative that captures the essence of the data.

To increase the validity of the conclusions, findings from the qualitative data will be triangulated with the quantitative results, ensuring a comprehensive understanding of the research outcomes. Interrater reliability measures will be implemented during the coding process to strengthen the credibility of the thematic analysis. Additionally, quotations used in reporting will be carefully selected to ensure that they are representative of participants' perspectives, avoiding cherry-picking to support preconceived notions. The researcher will also maintain reflexivity throughout the analysis process, acknowledging and addressing potential biases and perspectives that may influence the interpretation of the qualitative data.

The quantitative and qualitative findings will be integrated by triangulating the results from self-report questionnaires, interviews, and classroom observations. This approach ensures data validation and a comprehensive understanding. Quantitative data are statistically significant, whereas qualitative insights provide context and depth. Integration will occur during data analysis, interpreting themes and patterns across data sources. The mixed-methods

discussion synthesizes findings, highlighting convergent or divergent results to address the research question comprehensively.

Reliability and validity:

Questionnaires:

The reliability of the Metacognitive Awareness Inventory (MAI) is evidenced by its high internal consistency, with a Cronbach's alpha of 0.80, and strong test-retest reliability, with correlation coefficients of 0.75 over 2–3-week intervals. Similarly, the self-regulated learning inventory (SRLI) is reliable, with a Cronbach's alpha of 0.85 and test-retest correlation coefficient of 0.70.

For validity, the MAI's content validity is ensured through expert consultation and a literature review, whereas its criterion validity is supported by correlations with established metacognition measures (0.30--0.50). The construct validity was confirmed through factor analysis, which identified theoretical metacognitive constructs. The content validity of the SRLI aligns with Zimmerman's model, whereas its criterion validity is evidenced by correlations with other SRL measures (0.40--0.60). Cross-cultural validity ensures that both instruments are applicable across diverse contexts.

Educator interviews and classroom observations:

Reliability in both educator interviews and classroom observations is achieved through structured protocols and standardized rubrics, ensuring uniformity across data collection. Interrater reliability is bolstered by involving multiple researchers to independently code and compare findings, enhancing consistency in data interpretation.

Validity is strengthened through triangulation, where interview and observation data are cross-referenced with questionnaire results to identify converging insights. Member checking ensures accuracy by verifying summaries with participants, whereas peer debriefing refines findings through expert feedback. For classroom observations, longitudinal observation adds depth by capturing changes over time, and detailed contextual descriptions enrich the understanding of the educational environment.

By integrating these methods, the study ensures a robust, comprehensive approach to data reliability and validity, thereby enhancing the depth of quantitative findings and the overall conclusions.

Ethical Compliance: Informed Consent, Anonymity, and Participant Rights:

This study follows ethical standards, ensuring informed consent, confidentiality, and the right to withdraw at any time. Ethical considerations are crucial in online environments. The participants are informed about the purpose,

voluntary nature, and measures used to ensure the confidentiality and anonymity of the data collected during the observations.

Participants: Stratified Random Sampling of 300 University Students

The study involves a diverse sample of 300 students from various academic levels and cultural backgrounds enrolled in both online and traditional courses at the University of Tabuk. Participants will be selected via stratified random sampling to ensure representation across different disciplines and learning environments. The sample size of 300 students was determined through a power analysis to ensure sufficient statistical power to detect significant effects. Stratified random sampling was employed to ensure representation of diverse academic levels and cultural backgrounds, consistent with the study's objectives. This approach guarantees proportional representation within subgroups by academic level and cultural background, facilitating meaningful comparisons and enhancing the study's generalizability across demographic groups.

RESULTS

The study's results section summarizes the investigation into the use of metacognitive strategies in online and traditional education. This underscores the identification of significant trends that underscore the value of these strategies in improving student awareness and performance. The findings are categorized by each research instrument used, ensuring a structured presentation of the data. The researcher's rigorous analytical methods support the reliability of the results and align them with the study's goals.

Questionnaire: Quantitative findings on metacognitive strategy use and academic performance

The demographic characteristics of the participants (Table 1) summarize the demographic data of 300 study participants, who were evenly split between online and traditional learners, with an average age of 22.1 years. Females made up 52% of the sample, with 86% being undergraduates. The study's outcomes were more applicable across disciplines such as biology and English, indicating broad applicability across academic fields. The well-rounded demographics enhance the study's relevance and potential impact.

Table 1: Demographic characteristics of the participants

| Characteristic | Online Learners (n = 150) | Traditional Learners (n = 150) | Total Sample (N = 300) |
|-----------------------|----------------------------------|---------------------------------------|-------------------------------|
| Age (Mean \pm SD) | 22.5 \pm 3.2 | 21.7 \pm 2.8 | 22.1 \pm 3.0 |
| Gender | | | |
| Male | 69 (46.0%) | 75 (50.0%) | 144 (48.0%) |
| Female | 81 (54.0%) | 75 (50.0%) | 156 (52.0%) |
| Academic Level | | | |
| Undergraduate | 126 (84.0%) | 132 (88.0%) | 258 (86.0%) |
| Graduate | 24 (16.0%) | 18 (12.0%) | 42 (14.0%) |
| Discipline | | | |
| Biology | 38 (25.3%) | 40 (26.7%) | 78 (26.0%) |
| English | 42 (28.0%) | 35 (23.3%) | 77 (25.7%) |
| Computer Science | 32 (21.3%) | 39 (26.0%) | 71 (23.7%) |
| Business | 38 (25.3%) | 36 (24.0%) | 74 (24.7%) |

The descriptive statistics for the questionnaire scores (Table 2) summarize the scores related to metacognitive awareness and SRL. The Metacognitive Awareness Inventory (MAI) score is 3.72, indicating a slightly stronger grasp of cognitive knowledge than of cognitive regulation. The self-regulated learning inventory (SRLI) scores higher, with motivation and goal setting being the strongest areas. The responses generally lean toward the higher end, indicating positive engagement with metacognitive strategies. The range of scores indicates variation in experience with these strategies.

Table 2: Descriptive Statistics for Questionnaire Scores

| Questionnaire/Subscale/n=300 | Mean | Median | Mode | SD | Range |
|--|------|--------|------|------|-------|
| Metacognitive Awareness Inventory (MAI) | 3.72 | 3.80 | 4.00 | 0.58 | 2.10 |
| Knowledge of Cognition | 3.85 | 3.90 | 4.00 | 0.62 | 2.80 |
| Regulation of Cognition | 3.60 | 3.70 | 3.80 | 0.66 | 3.00 |
| Self-Regulated Learning Inventory (SRLI) | 3.90 | 4.00 | 4.20 | 0.51 | 2.50 |
| Motivation and Goal Setting | 4.10 | 4.20 | 4.40 | 0.72 | 3.20 |
| Learning Strategies | 3.75 | 3.80 | 3.90 | 0.67 | 3.00 |
| Self-Monitoring and Evaluation | 3.85 | 3.90 | 4.00 | 0.58 | 2.70 |

Table (3) shows the Pearson correlation coefficient, which measures the strength and direction of the linear relationship between metacognitive strategy use and academic performance. This figure illustrates the statistically significant correlations between metacognitive strategy use, as measured by the MAI and SRLI scores, academic performance indicators, and GPA and course grades. The correlations are strong, particularly between the SRLI score and GPA ($r = .51, p < .01$) and between GPA and course grade ($r = .72, p < .01$), suggesting that greater

engagement with metacognitive strategies is associated with better academic outcomes. The consistent positive correlations across all the variables reinforce the importance of metacognitive strategies for academic success. Importantly, the low p-values indicate the reliability of these findings, even if the data deviate slightly from normality.

Table 3: Correlations between metacognitive strategy use and academic performance/two-tailed tests

| Variable/n=300 | 1 | 2 | 3 | 4 |
|-----------------|-------|-------|-------|-------|
| 1. MAI Score | | .68** | .42** | .39** |
| 2. SRLI Score | .68** | | .51** | .47** |
| 3. GPA | .42** | .51** | | .72** |
| 4. Course Grade | .39** | .47** | .72** | |

Note: ** $p < .01$

The regression analysis (Table 4) presents a multiple regression analysis examining the influence of independent variables, including MAI and SRLI scores, on academic performance indicators such as GPA and course grades. This approach enables a comprehensive evaluation of multiple predictors simultaneously, with the analysis's validity supported by the normality of the data and the use of two-tailed tests. Statistically significant p values ($*p < .05$, $**p < .01$) confirm the robustness of the findings. Both MAI and SRLI scores emerge as significant predictors of GPA and course grades, as evidenced by strong positive standardized coefficients (β). Conversely, demographic factors such as age, gender, and discipline have negligible and nonsignificant effects. The model accounts for 38% of the variance in GPA and 32% in course grades, with adjusted R^2 values of 35% and 30%, respectively, indicating good model fit. These results highlight the critical role of metacognitive strategies, as measured by the MAI and SRLI scores, in predicting academic success, with particularly strong significance ($p < .01$) for the relationship between MAI scores and academic performance. Additionally, multiple regression results indicate that metacognitive awareness is a stronger predictor of academic performance than SRL motivation is, with

demographic factors showing minimal impact; the models account for 35–38% of the variance, suggesting other contributing factors.

Table 4: Multiple Regression Analysis Predicting Academic Performance/Two-tailed Tests

| Predictor Variable/n=300 | GPA | | Course Grade | |
|--------------------------|--------|---------|--------------|---------|
| | B | β | B | β |
| MAI Score | 0.60* | .59 | 0.70** | .60 |
| SRLI Score | 0.33** | .37 | 0.41* | .39 |
| Age | -0.02 | -.03 | -0.01 | -.01 |
| Gender | 0.06 | .04 | 0.09 | .05 |
| Discipline | -0.05 | -.07 | -0.03 | -.04 |
| R ² | .38 | | .32 | |
| Adjusted R ² | .35 | | .30 | |

Note: * $p < .05$, ** $p < .01$

The comparison of metacognitive strategy use between learning environments (Table 5) compares the use of metacognitive strategies between learners in online and traditional settings, utilizing Cohen’s d effect size to measure the magnitude of differences. While a normal data distribution is preferred, Cohen’s d remains reliable even with deviations, particularly for large samples. Traditional learners demonstrate slightly higher MAI and SRLI scores, with statistically significant differences observed in overall MAI scores, Regulation of Cognition, Learning Strategies subscales, overall SRLI scores, and the Self-Monitoring and Evaluation subscale. The effect sizes range from small to moderate, indicating that traditional learners engage more effectively with metacognitive strategies than do online learners. Statistical significance at $p < .05$ and $p < .01$ confirms the reliability of these findings.

Tables

Table 5: Comparison of metacognitive strategy use across learning environments/two-tailed tests

| Questionnaire/Subscale/n=300 | Online Learners/n=150 | Traditional Learners/n=150 | t | Cohen's d |
|--|-----------------------|----------------------------|---------|-----------|
| Metacognitive Awareness Inventory (MAI) | 3.65 ± 0.61 | 3.79 ± 0.54 | -2.11* | 0.24 |
| Knowledge of Cognition | 3.80 ± 0.65 | 3.90 ± 0.58 | -1.32 | 0.16 |
| Regulation of Cognition | 3.50 ± 0.69 | 3.69 ± 0.63 | -2.41** | 0.28 |
| Self-Regulated Learning Inventory (SRLI) | 3.81 ± 0.53 | 3.99 ± 0.48 | -2.96* | 0.35 |
| Motivation and Goal Setting | 4.05 ± 0.75 | 4.15 ± 0.69 | -1.11 | 0.14 |
| Learning Strategies | 3.65 ± 0.70 | 3.84 ± 0.63 | -2.39** | 0.28 |
| Self-Monitoring and Evaluation | 3.75 ± 0.60 | 3.95 ± 0.55 | -2.90* | 0.34 |

Note: * $p < .05$, ** $p < .01$

The comparison of metacognitive strategy use across disciplines (Table 6) examines the variance in metacognitive strategy utilization across academic disciplines using η^2 (eta squared) as a measure of effect size. This approach quantifies the differences in metacognitive strategy scores, providing insights into their magnitude. The findings, supported by statistically significant F-statistics and p-values ($p < .05$ and $p < .01$), confirm the reliability and robustness of the analysis. Among the four disciplines assessed—biology, computer science, English, and business—biology students reported the highest use of metacognitive strategies, particularly on the Regulation of Cognition subscale, on which they significantly outperformed business students. The effect sizes range from small to moderate, indicating meaningful but not pronounced differences. These results highlight the

variability in metacognitive strategy engagement across disciplines, with biology students demonstrating notably greater utilization.

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Table 6: Comparison of metacognitive strategy use across disciplines/two-tailed tests

| Questionnaire/Subs cale | Biology/ n= 78 | English /n= 77 | Computer Science/n = 71 | Business/ n= 74 | F | η ² |
|--|-------------------|-------------------|-------------------------------|--------------------|------------|----------------|
| Metacognitive Awareness Inventory (MAI) | 3.88 ± 0.52 | 3.65 ± 0.61 | 3.79 ± 0.56 | 3.56 ± 0.57 | 4.71* * | .04 6 |
| Knowledge of Cognition | 3.95 ± 0.58 | 3.80 ± 0.65 | 3.92 ± 0.60 | 3.72 ± 0.63 | 2.41* * | .02 4 |
| Regulation of Cognition | 3.81 ± 0.59 | 3.50 ± 0.69 | 3.66 ± 0.64 | 3.40 ± 0.63 | 6.50* * | .06 3 |
| Self-Regulated Learning Inventory (SRLI) | 4.02 ± 0.48 | 3.85 ± 0.53 | 3.94 ± 0.49 | 3.79 ± 0.51 | 3.56* * | .03 5 |
| Motivation and Goal Setting | 4.20 ± 0.68 | 4.08 ± 0.74 | 4.15 ± 0.70 | 3.95± 0.70 | 2.50* * | .02 5 |

Note: * $p < .05$, ** $p < .01$

Semi-structured Interviews: Educator Perspectives on Integrating Metacognitive Strategies Across Disciplines

Semi-structured interviews with ten educators from diverse disciplines provided qualitative insights into the integration of metacognitive strategies to

foster SRL. Educators reported using strategies such as planning, monitoring, and evaluating through activities such as reflective assignments, self-assessment tasks, and guided discussions. Scaffolding techniques have been widely employed to help students develop metacognitive skills progressively. While implementing these strategies in online settings has proven challenging due to limited engagement and a lack of face-to-face interaction, educators have identified opportunities in using digital tools to support learning reflection and progress tracking. Educators reported difficulties maintaining student engagement in virtual classrooms. For example, "In online courses, students often overestimate their understanding until exams reveal gaps. We addressed this by requiring weekly self-check quizzes with reflective prompts." (Participant E3, business administration)

Educators observed significant improvements in students' SRL abilities, including goal setting, time management, and self-evaluation. Enhanced academic performance and motivation are attributed to the effective application of metacognitive strategies.

The systematic institution-level integration of metacognitive strategies was emphasized. Educators highlighted the potential of instructional design, course materials, and learning management systems to embed these practices, alongside interdisciplinary collaboration for sharing best practices. Educators have advocated for professional development focused on metacognitive training and resources. They also recommended support systems to guide the implementation of these strategies across different disciplines and environments.

Collectively, these insights underscore the transformative potential of metacognitive strategies in enhancing SRL and academic outcomes. Educators' experiences and suggestions provide a practical framework for embedding metacognitive practices in curricula, emphasizing the need for institutional support and collaboration.

Classroom Observations: Instructional Practices and Metacognitive Strategy Implementation in Online vs. Traditional Settings

Classroom observations highlighted the implementation of metacognitive strategies in online and traditional learning environments, revealing their impact on student engagement and learning outcomes. Instructors employed planning strategies such as setting clear objectives, encouraging goal setting, and guiding resource organization. Monitoring was supported through reflective prompts, online tools for thought-sharing, and timely feedback. The evaluation strategies included self-assessments, peer reviews, and improvement identification. Students actively participated in discussions, demonstrated planning and evaluation skills, and utilized online tools for self-monitoring. Behaviors such as effective time management and resource seeking were also evident.

Instructors facilitated planning through clear objectives, material guidance, and goal-setting encouragement. Monitoring involved checking understanding, prompting thought sharing, and providing immediate feedback. The evaluation strategies included self-assessment, peer feedback, and reflection on learning adjustments. The students showed active participation, collaborative engagement, and the application of planning, monitoring, and evaluation strategies. They managed their time effectively, sought clarification, and adapted in response to feedback.

Both environments effectively incorporated metacognitive strategies but differed in execution. Online settings leverage digital tools for strategy implementation, whereas traditional classrooms benefit from real-time, in-person interactions and feedback. Each setting presented unique challenges and opportunities for enhancing SRL.

These observations provide valuable insights into the integration of practical metacognitive strategies, demonstrating their effectiveness in fostering SRL across diverse educational contexts. The findings offer guidance for tailoring these strategies to maximize their impact in both online and traditional settings.

DISCUSSION

This study investigated the role of metacognitive strategies in fostering SRL across online and traditional classroom environments. The key findings revealed a strong positive correlation between metacognitive strategy use, as measured by the MAI and SRLI scores, and academic performance indicators such as GPA and course grades. Additionally, the regression analysis identified MAI and SRLI scores as significant predictors of academic success, further underscoring the importance of metacognitive strategies in enhancing learning outcomes.

These findings align with the literature that highlights the crucial role of metacognitive awareness and strategy use in promoting SRL and academic achievement (Alvarez et al., 2022 & Bannert et al., 2015). By employing strategies such as planning, monitoring, and evaluating their learning processes, students can effectively regulate their cognition, motivation, and behavior, ultimately leading to improved performance (Zimmerman, 2002).

The study also revealed notable differences in the use of metacognitive strategies between online and traditional learners. Traditional learners scored higher on overall MAI and SRLI, as did specific subscales, such as Regulation of Cognition and Learning Strategies. While the effect sizes were small to moderate, these findings suggest that face-to-face interaction and immediate feedback in traditional classrooms may better facilitate the development and application of metacognitive strategies (Acosta-Gonzaga & Ramirez-Arellano, 2021). However,

online learning environments offer unique opportunities to integrate online tools and resources that support metacognitive processes (Wong et al., 2019).

Interestingly, the study revealed variations in the use of metacognitive strategies across academic disciplines. Biology students reported the highest levels of engagement with metacognitive strategies, followed by those in computer science, English, and business. These differences could be attributed to the inherent nature of the disciplines, with some fields requiring a more explicit application of metacognitive processes than others. Nonetheless, the findings highlight the importance of tailoring metacognitive strategy instruction to the specific needs and contexts of different disciplines.

The qualitative data from educator interviews and classroom observations provided valuable insights into the practical implementation of metacognitive strategies across different learning environments. Educators highlighted the challenges and opportunities associated with integrating these strategies, particularly in online settings. They emphasized the need for systematic curricular integration, institutional support, and professional development opportunities to increase the effectiveness of metacognitive strategy instruction.

Several recommendations can be made on the basis of the findings of this study. First, educational institutions should prioritize the explicit teaching of metacognitive strategies across all disciplines and learning environments. This could involve incorporating metacognitive training into instructional design, course materials, and learning management systems. Second, interdisciplinary collaboration among educators is crucial for sharing best practices and tailoring metacognitive strategy instruction to the unique needs of different fields. Third, professional development programs and resources should be developed to equip educators with the necessary skills and knowledge to effectively integrate metacognitive strategies into their teaching practices.

Furthermore, future research should explore the potential of emerging technologies and online tools in supporting metacognitive processes, particularly in online and blended learning environments. Additionally, investigating the interplay between metacognitive strategies, SRL, and other factors, such as motivation, self-efficacy, and socioemotional skills, could provide a more holistic understanding of the factors influencing academic success.

This study's findings have significant theoretical implications that warrant further exploration. An analysis of how the results align with and extend existing models of metacognition (Flavell) and SRL (Zimmerman) could provide valuable insights into the domain-general versus domain-specificity of metacognitive processes across academic disciplines. Furthermore, examining the interplay between metacognitive strategy use and other cognitive factors, such as working memory and prior knowledge, may elucidate the underlying mechanisms that facilitate learning. Methodological considerations should also be addressed, such as critically evaluating the self-report measures employed and exploring

alternative assessments (e.g., think-aloud protocols) that could triangulate findings through mixed methods approaches. The incorporation of learning analytics techniques could yield nuanced understandings of students' metacognitive processes.

From a pedagogical perspective, this research highlights the need for evidence-based instructional strategies and classroom activities tailored to cultivating metacognitive abilities across various disciplines. Teacher training programs must prioritize equipping educators with the skills to effectively model and integrate metacognitive practices into their teaching. The use of instructional technologies and adaptive learning environments provides opportunities to embed metacognitive support and scaffolding. Moreover, investigating individual differences in factors such as motivation, self-efficacy, and learning styles could shed light on how interventions may have differential impacts on the basis of students' metacognitive awareness and developmental levels. Exploring demographic variables could also uncover potential disparities in metacognitive strategy use. Collectively, these areas underscore the theoretical depth and practical significance of promoting metacognition to enhance SRL and academic success.

While the study yielded encouraging outcomes, it is important to acknowledge its limitations for a balanced view. The sample size, although considerable, may not encapsulate the full diversity of higher education institutions and academic disciplines. The use of self-report measures as the primary tool for assessing metacognitive strategy use could bias the results due to inherent biases. To enhance the validity of future research, a multifaceted approach integrating self-report methods with performance-based evaluations and longitudinal analyses is recommended. This would offer a more nuanced exploration of how metacognitive strategies influence SRL and, consequently, academic success. Moreover, it is crucial to consider the Hawthorne effect's potential impact on the study's observational component, in which participant behavior may be modified by the awareness of being observed.

In conclusion, this study contributes to the growing body of literature on the importance of metacognitive strategies in promoting SRL and academic achievement. By systematically integrating these strategies into curricula across disciplines and learning environments, educational institutions can empower students to become more self-aware, reflective, and effective learners. The findings underscore the need for a concerted effort from educators, institutions, and researchers to enhance metacognitive strategy instruction and support, ultimately fostering a culture of lifelong learning and success.

CONCLUSIONS

This study provides compelling evidence for the pivotal role of metacognitive strategies in fostering SRL and enhancing academic achievement across disciplines. By systematically integrating metacognitive practices into curricula and instructional approaches, educational institutions can empower students to become more self-aware, reflective, and effective learners. However, successful implementation hinges on addressing key considerations, including tailoring strategies to domain-specific needs, utilizing technological affordances, and equipping educators with requisite training. Furthermore, continued research is imperative to elucidate the complex interplay between metacognitive processes, individual differences, and contextual factors that shape learning outcomes. Nonetheless, the findings underscore the potential of metacognition as a powerful catalyst for cultivating lifelong, self-directed learning abilities essential for success in an ever-evolving educational landscape and beyond.

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