Do Metacognitive Strategies Work? Moodle as a BCSS Tool to Enhance Self-Regulated Learning Behavior in Software Engineering Students

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Abstract

A central challenge for humans is changing their behavior, even when they want to. Conversely, people often seek alternative methods to monitor and control their cognitive processes, mediating behavior through self-regulation with metacognitive strategies encompassing goal setting, planning, monitoring, evaluating, and adjusting their learning behaviors. This includes modern technology-mediated tools like Moodle as behavior change support systems (BCSS). We conducted a case study within a master's degree module (Sustainability and IT) of LUT University, Finland, where students earned credits by engaging in self-study online via Moodle. We examined their course feedback to assess their Self-Regulated Learning (SRL) and evaluated whether the self-study online module met their SRL needs. The study's results indicated that students were satisfied with the self-study module facilitated by Moodle. The metacognitive strategies are effective when there is a direct link to the module's practical implementation. However, goal setting and planning always present challenges, while other components of metacognitive strategies (monitoring, evaluating, and adjusting) help promote effective learning behaviors. Future research should consider designing BCSSs that prioritize goal setting in self-study using Moodle and similar tools

Keywords

Self-Regulated Learning, Metacognition Strategy, BCSS, Learning Behavior

1. Introduction

SRL (Self-Regulated Learning) describes active and dynamic processes whereby learners monitor and control their own cognitions, affects, and behaviors to achieve personal learning goals [1][2]. When engaging in SRL, learners use various strategies to optimize their learning process and to achieve their goals. These SRL strategies include cognitive (e.g., rehearsal, elaboration), metacognitive (e.g., planning, monitoring), and resource management (e.g., time management, help-seeking) strategies [3]. In empirical studies, SRL strategies have been linked to learning performance [4][5].

The continuous rapid evolution of digital technologies has fundamentally transformed the educational paradigm, especially in higher education institutions (HEIs). Moreover, the increasing complexity of the curricula in software engineering programs, coupled with the digitalization of education in HEIs, demands that students develop effective self-regulated

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learning (SRL) skills to manage their learning processes effectively and autonomously [6]. Metacognitive strategies enable students to effectively monitor, evaluate, and plan/adjust their learning processes. They have been shown to enhance academic performance and problem-solving skills, particularly in STEM fields [4][7]. However, fostering these strategies in HEIs, particularly in the context of software engineering education, remains a challenge.

With the rise of digital learning environments, Learning Management Systems (LMS) such as Moodle offer an opportunity to integrate structured Behavior Change Support Systems (BCSSs) to facilitate self-regulated learning [8]. A BCSS is designed to guide, motivate, and reinforce positive behavioral change through digital interventions [9]. BCSS principles—such as goal-setting prompts, self-reflection exercises, and progress tracking—can enhance students' metacognitive engagement when strategically embedded within Moodle.

Software engineering master's students are characterized by high technological literacy and complex learning demands, including technical and advanced metacognitive skills [10]. Metacognitive awareness enhances learning efficiency and develops more significant problem-solving capacities in technical disciplines [1]. Yet, limited research has systematically examined its implementation and effectiveness in engineering education at the master's level [11]. While some studies suggest that technology-enhanced platforms can integrate metacognitive strategies into engineering curricula, empirical evidence assessing their impact remains scarce [12][13]. Addressing these gaps is crucial to optimizing educational methodologies and preparing students for lifelong learning in a rapidly evolving technological landscape. Despite the increasing adoption of Moodle-based interventions, research on its efficacy as a BCSS tool for fostering metacognitive learning strategies remains limited, particularly within the software engineering domain. Given engineering education's self-directed and project-based nature, understanding whether Moodle can effectively scaffold SRL behaviors is crucial.

This study investigates the impact of metacognitive strategies implemented via structuring Moodle as a BCSS to enhance SRL among software engineering students in an MSc-level course (module code: Sustainability and IT). We evaluate how Moodle-based interventions influence students ' ability to regulate their learning by using empirical data collected through Moodle interactions, self-reported surveys, and academic performance metrics. By examining how targeted digital interventions can promote SRL, we seek to contribute empirical insights into technology-enhanced learning methodologies and their potential to transform educational practices in the software engineering discipline.

2. Self-regulated learning (SRL)

According to self-regulated learning (SRL) theories, learners engage in their learning processes and can track and control various aspects of their education [1][2]. The authors proposed that SRL comprises three cyclical phases. This includes 1) *the forethought phase*, in which learners analyze the learning task, set goals, and develop plans to achieve these objectives; 2) *the performance phase*, in which learners execute the previously created plan while monitoring and managing their learning progress; 3) *the self-reflection phase*: learners evaluate their performance and learning goals. This assessment may prompt them to adjust their strategies for future learning sessions and can impact subsequent forethought phases [14]. All learners self-regulate their learning process to some degree [15].

Nevertheless, effective self-regulators are characterized by their standard utilization of SRL strategies [16]. SRL strategies have been conceptualized differently across SRL theories, but they can be widely classified into cognitive, metacognitive, and resource management strategies [17]. *Cognitive strategies* facilitate processing information from learning materials [18]. *Metacognitive strategies* entail second-order cognitions that support learners in monitoring and controlling their cognition and applying cognitive strategies. Metacognitive strategies involve goal setting and planning, monitoring, evaluating, and adjusting one's learning behavior. *Resource management strategies* outline strategies for regulating internal and external resources (such as time and effort) besides cognition [1][17].

Self-regulated learning promotes practices that cultivate students' metacognition, motivation, and strategic action development. These essential learning competencies improve students' academic performance and learning outcomes [19]. Therefore, in this study, we analyzed their course feedback and whether the self-study-based online module fulfilled their self-regulated learning needs to evaluate their Self-Regulated Learning (SRL) behavior.

3. LUT Sustainability and IT module as a case study

In this study, we applied for a master-level course (Sustainability and IT) at LUT University, Finland. Case studies can *describe, explain,* or *explore* events or phenomena in the daily contexts in which they occur [20]. For instance, it can help understand and explain causal links and pathways resulting from a new service development [20], such as a master-level course facilitated by the LMS-based platform Moodle, by integrating the concept of BCSS. The case study approach allows, among other things, to study critical events, interventions, policy developments, and program-based service reforms in a real-life context [21].

At LUT University in Finland, master's level courses are designed for software engineering students to further explore sustainability by linking IT with aspects of 21st-century applications. The entire course or module offers 6 ECTS credits; students can complete it online or on-site. Our current study focused on the online format for the fall semester, which is structured explicitly for self-study. This course includes materials such as a textbook for reading and extracting key insights; other assignments involve reflective writing, pre-task activities based on videos, and current news on sustainability. All study materials and task-related activities are accessible through the LUT student's Moodle account. The course provides schedules, timelines, a detailed description, and announcements regarding completing and submitting readings and assignments online. Students are always encouraged to contact the instructors via Moodle queries for study-related inquiries. An online forum is available within Moodle for sharing and seeking feedback on self and peer evaluations (see Figure 1).

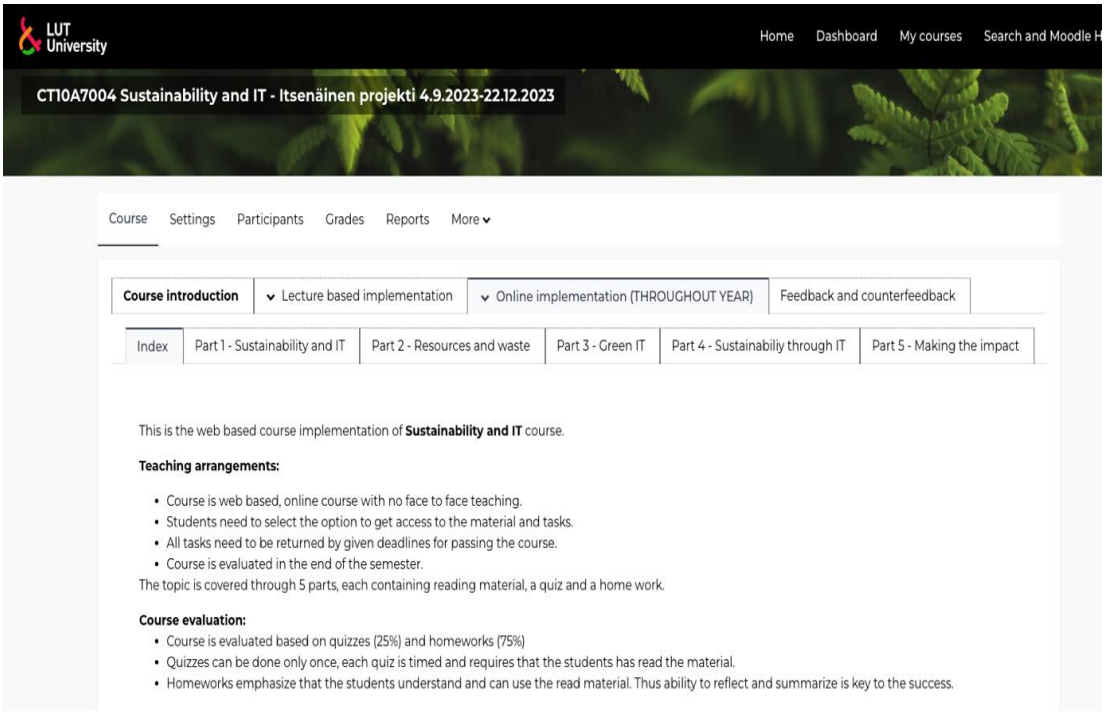

Figure 1: Sustainability and IT Course Design into Moodle LMS platform

In this study, we chose two consortia. We gathered data on the course design and students' data related to the assignments to analyze whether SRL increases learning behavior among them (see Table 1-3).

Table 1
LUT Sustainability and IT course and student details

Student group	Course design methods (range from 0-5)	Learning (score range from 0-5)	Feedback survey (completed students)	Enrolled students	Course completion, rate
Consortium fall 2024	4.5	4.3	4	23	12 (52%)
Consortium fall 2023	3.4	3.7	15	34	17 (52%)

In the consortium for fall 2023, 15 out of 34 registered students completed the feedback survey, while 4 out of 23 enrolled students completed the course feedback survey (on a Likert scale of 0-5) in the consortium for fall 2024. The average responses from the students are presented below (Table 1). Survey questions focused on the workload related to study credits, teaching methods, course design (specifically whether the course supported their learning), and whether the course enhanced their knowledge, understanding, and education, among other aspects. However, only four students completed the feedback survey in 2024. This may

be attributed to the exam period, which could have limited students' time to complete the survey questions

Table 2
The table provides an overview of different SRL strategies identified in previous literature and the features we applied to our Sustainability and IT course. It utilizes Moodle as a BCSS tool to connect the metacognitive strategies.

Strategy	Description	Moodle feature connecting the metacognitive strategies
Goal setting	Thinking about what needs to be learned, setting learning goals, and building a plan (e.g., a study schedule) to approach these goals [17]	The course timeline and details are provided in the introduction
Self-monitoring	Self-observing the present learning progress, knowledge, or mastery of the learning contents [17]	Download the course materials, read, observe and track if all the books and reading files has been studied and need to further study or not for the final assignment submission
Self-evaluation and reaction	Reflecting and assessing one's learning performance about learning goals and altering an individual's learning behavior for future learning sessions [16][17]	Task submission into sub-section online link - as a chapter review assignment submission, and thinking about the next submission by judging the previous one
Self-satisfaction	Recognizing the intrinsic value of the present learning activity (e.g., its relation to long-term goals or personal interests [22]	Reading the books and other submitted materials. Submitting the course quizzes and assignments, and showing the “submitted” green gamified option
Metacognitive self-regulation	Composite score of metacognitive strategies including planning, monitoring, and regulating learning processes [16]	Repitatively looking to study materials from the sub-sections of study phases Repitatively focusing on learning outcomes as per mentioned by the course structure

Following Table 2, we have constructed our Sustainability and IT Moodle course by merging the SRL metacognition strategy of goal-setting, self-monitoring, self-evaluation, and metacognitive self-regulation. This was done by systematically analyzing the weekly structure of the entire module, followed by the learning method (see Table 3).

Table 3
Sustainability and IT Moodle course linking up SRL.

Time	Method of learning	Metacognition strategy
Pre-week	Videos and materials	Self-monitoring
Week 1	Lecture on introduction to the module Summary of the module	Goal setting Self-evaluation
Week 2	Self-study of book chapters Own Assesment of chapter review assigment	Self-monitoring Self-evaluation
Week 3	Self-study of book chapters Own assesment of chapter review assigment	Self-monitoring Self-evaluation
Week 4	Self-study of book chapters Own assesment of chapter review assigment	Self-monitoring Self-evaluation
Week 5	Self-study of book chapters Final deliverables submission	Self-monitoring Self-satisfaction
Week 1-5	Iterative self-task of quizzes	Meta-cognitive self-regulation

Students submitted written feedback after completing their course timeline. An automated email was sent with a 5-point Likert scale (ranging from very true to not true). The feedback questions primarily focused on the course design method and learning experiences. Additionally, semi-structured interviews [23] were conducted with selected students who had completed the self-study courses. They were asked about external contexts and their opinions and feelings regarding the Moodle-based Sustainability and IT course, which emphasizes their metacognitive strategies, including goal setting, self-monitoring, self-evaluation, and metacognitive self-regulation. The first author performed conventional content analysis to evaluate the responses to open-ended questions. Microsoft Excel (Microsoft Corp, Redmond, WA) was used to store and organize the data collected during the interviews. The analysis unfolded in three steps: (1) the data were read multiple times for familiarity, (2) words relating to key themes were identified and coded, and (3) the context and frequency of theme-related sentences were recorded.

4. Principal findings

4.1. Course feedback

The course feedback from the consortium in the fall 2024 session was more productive regarding course design methods and self-study learning modes (see Table 1). This enhancement resulted from the feedback received in the 2023 session, which prompted us to update the materials and improve the complexity of the quizzes, making it easier for students

to complete self-assignments. Yet, the course workload is almost identical for both consortiums (see Fig 2).

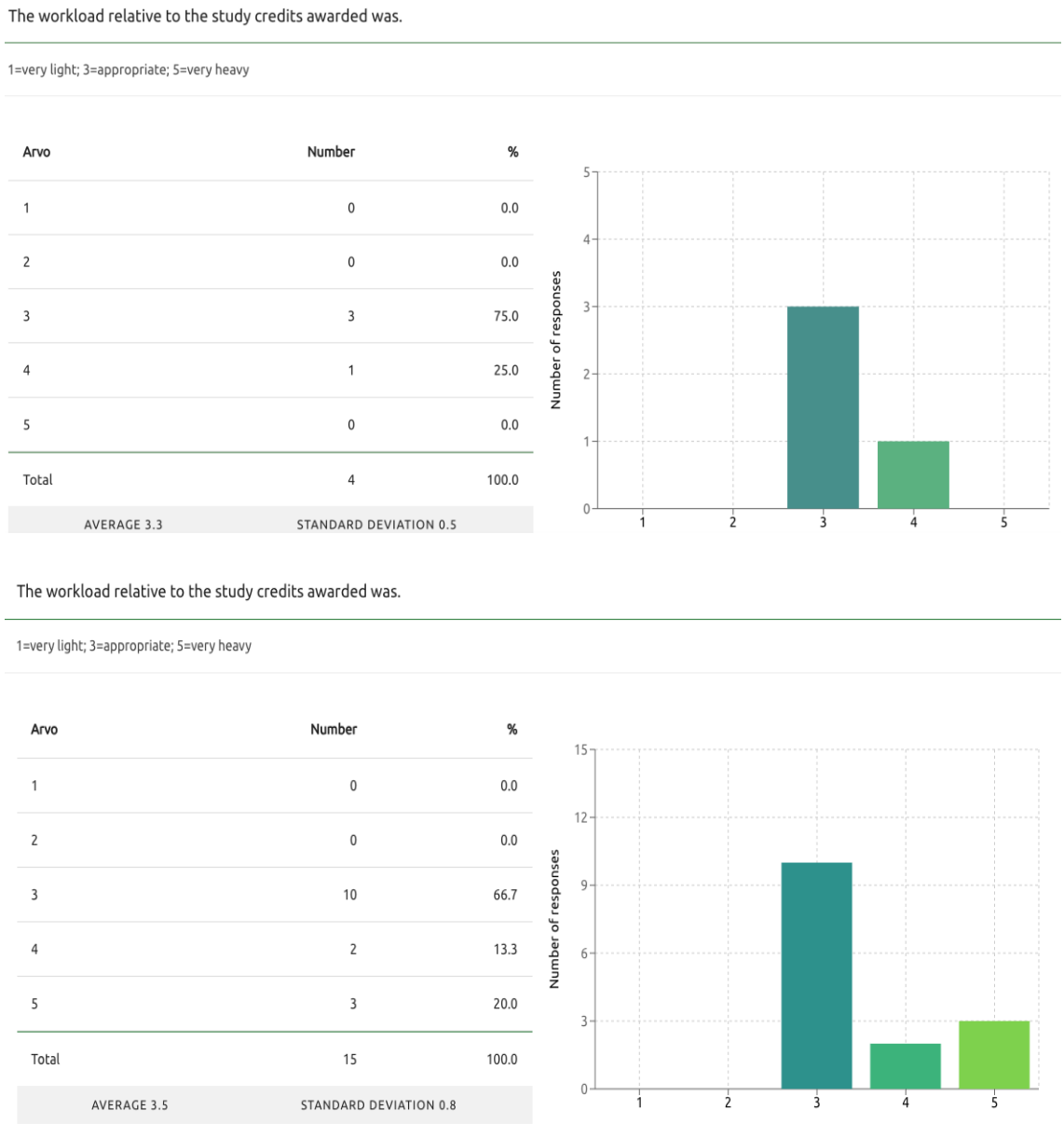

Figure 2: Workload data from students' feedback survey (the upper screenshot is from the Consortium Fall 2023 session, while the lower screenshot is from the Consortium Fall 2024).

4.2. Open questions

Seven students who completed an online study were interviewed semi-structuredly [23]. The questions focused on their experience with goal-setting, self-monitoring, self-satisfaction, and self-evaluation.

4.2.1. Goal-setting

Most participants (6/7, 85%) noted that goal setting can be hectic and time-consuming. Engaging in self-study is often tricky, making completing the course on time challenging. Others suggested that this may stem from a lack of motivation to finish the course, which should be engaging.

4.2.2. Self-monitoring

Students (7/7, 100%) highlighted that they accessed the course materials and tracked whether all the books and reading files had been studied and needed further study. In this way, they re-iterate self-monitoring by analyzing and checking the assignment submission or re-submission from time to time, as well as the tasks needed to proceed to the next section of the module.

4.2.3. Self-satisfaction

Participants found self-satisfaction with the course and realized the online self-study option (7/7, 100%). A participant stated, “I found it very good that we were allowed to choose between the option to do the course online or in class, so everyone could decide what fits best to their learning style.” The course excellently conveyed the intricate relationship between IT and sustainable development, providing a holistic understanding of both the negative and positive impacts while imparting practical strategies to reduce IT footprints and leverage technology for broader sustainability goals”.

4.2.4. Self-evaluation

Students (5/7, 71%) mentioned that the course online portal from the Moodle platform downloads the materials to read, and when submitting their tasks to the online portal. This allowed them to submit tasks as chapter review assignments and consider the next submission by judging the previous one.

4.2.5. Metacognitive self-regulation

Students (7/7, 100%) felt some metacognitive self-regulation as they read the books and other submitted materials. By submitting the course quizzes and assignments and seeing the “submitted” green gamified option, they reported, "The course provides a solid foundation on IT's role in sustainability but could benefit from more practical applications and updated content reflecting the latest advancements in green technology."

5. Lesson-learned

5.1. Students do not like complex quizzes for self-evaluation

For the online implementation, the quizzes are challenging, making them time-consuming and hectic for students. The course materials come from previous years, so updated content is necessary if available. The issue regarding the ‘quizzes’ is somewhat complex to address. This relates to critical thinking tests [24], which some students may find challenging; however, it is beneficial as it encourages the exploration of sustainability. Future designs may modify some aspects of these or their structure.

5.2. Self-study students don't seek bonus points; they aim to learn and complete their work

Students are more likely to strive for knowledge and complete their work. They highlighted course independence and described it as "Independent learning, not forced to watch lectures, self-studying, and interesting topics (especially the hardware part). " This may stem from their intrinsic motivation to learn and natural curiosity [25], which drives students to seek challenges and develop the skills necessary to complete their work.

5.3. No craving for early grading as students were competent and felt four learning outcomes

Students did not request early grading after submitting their assignments. They wanted to wait and monitor themselves until the right time came to realize whether they had successfully finished the course. This may be because they felt satisfied with their quizzes and assignment-related tasks and believed they were competent [26]. Also, students may feel four possible learning outcomes of increasing levels of effectiveness in our self-study-based Moodle course: entertainment, updating knowledge and skills, unexpected learning, and effective learning [27].

5.4. Recommendations

This study has contributed to SRL theory [19], giving students greater control over their learning. Students focused on implementing a project-based self-study model to apply their knowledge in practical environments. However, after completing the course, they felt uncertain about how to utilize their knowledge. Students' levels of autonomy are relatively low [26], possibly due to difficulties in setting personal goals. The study's results indicated that students were satisfied with the self-study module facilitated by Moodle. Engaging students in a planned manner, such as through a Moodle-based course incorporating student reflection, planning, goal setting, and self-assessment, positively impacts self-efficacy and writing outcomes [28]. Metacognitive strategies are effective when directly linked to the module's practical implementation. However, goal setting and planning consistently present challenges, while other components of metacognitive strategies (monitoring, evaluating, and adjusting) promote effective learning behaviors.

5.5. Further directions

Future research should focus on designing BCSSs that prioritize goal setting in self-study using Moodle and/or similar tools. This could be done by setting a timeline to set goals in a gamified environment with avatars so that students enjoy their self-study and task submission [29]. We conducted interviews only with students who completed self-study courses, but we also needed to identify those who dropped out or did not finish the online self-study course, and the real causes. Furthermore, future studies should aim to develop a Moodle course that helps students set goals to facilitate their course completion. The empirical analysis should be conducted with students e.g., collecting blind peer-review feedback from other students and teachers [30].

References

[1] Pintrich, P.R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), Handbook of self-regulation (pp.451–502). Academic Press.

[2] Zimmerman, B.J., & Schunk, D.H. (2011). Self-regulated learning and performance: An introduction and an overview. In D.H. Schunk, & B. J. Zimmerman (Eds.), Handbook of self-regulation of learning and performance (pp. 1–12). Routledge.

[3] Pintrich, P.R., Smith, D.A.F., Garcia, T., & McKeachie, W.J. (1991). A manual for the use of the motivated strategies for learning questionnaire (MSLQ). National Center for Research to Improve Postsecondary Teaching and Learning.

[4] Chaker, R., & Impedovo, M.A. (2021). The moderating effect of social capital on co-regulated learning for MOOC achievement. Education and Information Technologies.

[5] Haemer, H.D., Borges-Andrade, J.E., & Cassiano, S.K. (2017). Learning strategies at work and professional development. Journal of Workplace Learning, 29(6), 490–506.

[6] Zimmerman, B.J. (2002) Becoming a self-regulated learner: An overview. Theory into practice.

[7] Haemer, H.D., Borges-Andrade, J. E., & Cassiano, S.K. (2017). Learning strategies at work and professional development. Journal of Workplace Learning, 29(6).

[8] Lehto, T., & Oinas-Kukkonen H. (2011). Persuasive features in web-based alcohol and smoking interventions: a systematic review of the literature. JMIR

[9] Oinas-Kukkonen, H. (2013). A foundation for the study of behavior change support systems. Personal and ubiquitous computing. 17:1223-35.

[10] Hidayat, H., Harmanto, D., Isa, MM, Tanucan, J., Ahlunnazak, A., Ifdil, I., & Ardi, Z. (2024). Importance of Metacognitive Awareness in Learning and Instruction for Engineering Students' Education. Journal of Social Studies Education Research.

[11] Felder, R.M., & Brent, R. (2024). Teaching and learning STEM: A practical guide. John Wiley & Sons.

[12] Anthonysamy, L. (2021). The use of metacognitive strategies for undisrupted online learning: Preparing university students in the age of pandemic. Education and information technologies. 26(6):6881-99.

[13] Tran, T.M, & Hasegawa, S. (2022). An empirical study on the relationship between cognition and metacognition in technology-enhanced self-regulated learning. Sustainability.

[14] Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. Frontiers in Psychology, 8, Article e422.

[15] Winne, P.H. (2022). Modeling self-regulated learning as learners doing learning science: How trace data and learning analytics help develop skills for self-regulated learning. Metacognition and Learning, 17(3), 773–791.

[16] Pintrich, P.R., Smith, D.A.F., Garcia, T., & McKeachie, W.J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). Educational and Psychological Measurement, 53(3).

[17] Theobald, M. (2021). Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: A meta-analysis: Contemporary Educational Psychology, 66, Article e101976.

[18] Winne, P.H. (2011). A cognitive and metacognitive analysis of self-regulated learning. In D. H. Schunk, & B. J. Zimmerman (Eds.), Handbook of self-regulation of learning and performance (pp. 15–32). Routledge.

[19] Brenner, C.A. (2022). Self-regulated learning, self-determination theory and teacher candidates' development of competency-based teaching practices. *Smart Learn. Environ.*

[20] Yin, R.K. (2009). Case study research, design and method. 4. London: Sage Publications
[21] Crowe, S., Cresswell, K., Robertson, A., Huby, G.A., Avery A. A. & Sheikh, A.(2020). The case study approach. BMC medical research methodology. 2020 Feb;11(1):100.
[22] Fontana, R.P., Milligan, C., Littlejohn, A. & Margaryan, A. (2015). Measuring self-regulated learning in the workplace. International Journal of Training and Development.
[23] Kallio, H., Pietilä, A.M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. J Adv Nurs, 72(12):2954-2965.
[24] Ku, Y.L.K (2009). Assessing students' critical thinking performance: Urging for measurements using multi-response format, Thinking Skills and Creativity, Elsevier
[25] Kum, B.A. (2022). The effects of intrinsic and extrinsic motivation on student learning effectiveness (Case study: International students of Estonian Entrepreneurship University of Applied Sciences)
[26] Haque, S., O'Broin, D., & Kehoe, J. (2020). Effects of daily routine on students' SDT needs satisfaction: a pilot study towards developing a digital gamified system. In Proceedings of GAME-ON: 21st Annual European GAME-ON'2021 Conference on Simulation and AI in Computer Games, Universidade de Aveiro, Portugal, Eurosis-ETI.
[27] Rof, A., Bikfalvi, A., Marques, P. (2024). Exploring learner satisfaction and the effectiveness of microlearning in higher education, The Internet and Higher Education,
[28] Chung, H.Q., Chen, V. & Olson, C.B. (2021). The impact of self-assessment, planning and goal setting, and reflection before and after revision on student self-efficacy and writing performance. Read Writ 34, 1885–1913.
[29] Haque, M.S., O'Broin, D., Kehoe, J. (2017). Designing a Gamified Theory-Driven System Model for Postgraduate Research Students to Encouraging Progression and Social Connectedness, ECGBL.
[30] Haque, M. S., Iyengar, S., Karppinen, P., van Gemert-Pijnen, L., & Oinas-Kukkonen, H. (2023). What do we know about behavior change support systems after a decade of annual meetings? In Proceedings of the 11th International Conference on Behavior Change Support Systems: Hybrid Event, Hosted by the Eindhoven University of Technology, Eindhoven, The Netherlands.