

CHATGPT AS A SCAFFOLDING TOOL FOR STUDENTS' SELF-REGULATED LEARNING: A SYSTEMATIC LITERATURE REVIEW

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Abstract. The development of ChatGPT and generative artificial intelligence (GenAI) has opened new opportunities to support students' self-regulated learning (SRL). This study aims to systematically examine the role of ChatGPT/GenAI as a scaffolding tool in strengthening SRL. The method used is a systematic literature review by following the PRISMA flow. Articles are obtained from Scopus, ScienceDirect, and SpringerLink databases with a publication span of 2023–2025. Of the 268 initial articles, 24 articles met the inclusion criteria and were analyzed thematically. The results of the study show that ChatGPT/GenAI plays a role in several forms of scaffolding, namely metacognitive scaffolding, feedback scaffolding, reflective-dialogic scaffolding, writing-process scaffolding, motivational scaffolding, collaborative scaffolding, and AI literacy scaffolding. The most supported SRL dimensions include planning, monitoring, feedback use, help-seeking, reflection, self-evaluation, strategy adjustment, learner autonomy, motivation, and self-efficacy. However, the use of ChatGPT/GenAI also presents challenges, including over-reliance, superficial use, hallucinations, limited personalization, weak social presence, and academic ethical issues. This study confirms that ChatGPT/GenAI is effective as a scaffolding tool when used through a directed, reflective, critical, and ethical learning design.

Keywords: ChatGPT, generative artificial intelligence, scaffolding tool, self-regulated learning, systematic literature review

INTRODUCTION

The development of generative artificial intelligence (GenAI), especially ChatGPT, has changed the way learners access information, complete academic assignments, receive feedback, and organize their learning. ChatGPT is used not only as an answer-seeking tool but also as a learning assistant that helps students understand material, organize ideas, revise writing, solve problems, and reflect on the learning process. Several studies show that ChatGPT has the potential to support active learning, knowledge construction, and improved academic performance when used in the right learning design (Li, 2023; Lee et al., 2024; Ng et al., 2024). In the context of higher education, the presence of ChatGPT is increasingly relevant because students are required to demonstrate independence, critical thinking, digital literacy, and the ability to manage their learning.

Self-regulated learning (SRL) is an important concept for understanding how students manage their learning process in an AI-based digital environment. SRL refers to learners' ability to set goals, plan strategies, monitor understanding, seek help, use feedback, evaluate outcomes, and adjust learning strategies. In the context of using ChatGPT, several studies show that GenAI can strengthen the SRL dimension through planning, monitoring, feedback, reflection, and self-evaluation. Ng et al. (2024) found that ChatGPT can empower SRL in science learning, while Wu et al. (2024) show that ChatGPT-based learning aid can support the development of self-regulation

and knowledge construction in blended learning. Weng et al. (2024) also emphasized that the use of ChatGPT in SRL is influenced by learners' characteristics, including self-regulation tendencies and their use of AI in learning.

From a scaffolding perspective, ChatGPT/GenAI can be understood as a learning tool that provides temporary, targeted support to help students complete academic tasks more independently. This role appears in various forms, such as metacognitive scaffolding, feedback scaffolding, reflective-dialogic scaffolding, writing-process scaffolding, and motivational scaffolding. Neshaei et al. (2025) show that large language models can reinforce reflective writing through metacognitive support, while Banihashem et al. (2024), Meyer et al. (2024), and Sun et al. (2025) show that AI-generated feedback can help learners make revisions, increase engagement with feedback, and improve learning strategies. In language learning and academic writing, ChatGPT has also been reported to contribute to learner autonomy, self-efficacy, and revision practices (Nguyen & Doan, 2025; Tran, 2025; Yang et al., 2025).

However, the use of ChatGPT/GenAI in SRL does not always automatically have a positive impact. Undirected use can lead to overdependence, superficiality, weak information verification, and reduced metacognitive effort. Fan et al. (2025) warn of the emergence of metacognitive laziness when learners rely too much on GenAI in the learning process. In addition, Tankelevitch et al. (2024) argue that the use of GenAI poses new metacognitive demands, as learners must design prompts, evaluate responses, and control the interaction process with AI. Therefore, integrating ChatGPT into learning should be accompanied by AI literacy, feedback literacy, academic ethics, and pedagogical design that encourage students to think critically, reflectively, and responsibly.

Based on these developments, a systematic study of ChatGPT/GenAI as a scaffolding tool in SRL is warranted. Various studies have discussed ChatGPT in the context of learning, academic writing, feedback, motivation, and learning performance, but the mapping that specifically positions ChatGPT as a scaffolding tool to strengthen the SRL dimension still needs to be more systematically structured. Therefore, this article aims to systematically examine the forms of ChatGPT/GenAI scaffolding, the SRL dimensions supported, the learning outcomes that emerge, the conditions that strengthen its effectiveness, and the challenges of its use. This study is expected to provide a conceptual and practical basis for the development of AI-based learning that is not only oriented towards learning outcomes, but also on strengthening students' independence, reflection, and learning responsibility.

METHODS

Research Design

This study uses a Systematic Literature Review (SLR) design to identify, select, analyze, and synthesize articles on the role of ChatGPT as a scaffolding tool for students' Self-Regulated Learning (SRL). The article selection process follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram, ensuring that the stages of searching, screening, feasibility assessment, and final article selection are conducted systematically and transparently. This study focuses on English-language articles published in 2023–2025 relevant to educational psychology, particularly those that discuss self-regulated learning, metacognition, learning motivation, learner autonomy, feedback, reflection, and the use of generative artificial intelligence in learning.

Database and Article Search Strategies

Article searches are conducted across three scientific databases: Scopus, ScienceDirect, and SpringerLink. The three databases were chosen for their wide scope of international publications and relevance to the fields of education, psychology, learning technology, and artificial intelligence in education. The search keywords were compiled by combining terms related to ChatGPT, generative artificial intelligence, scaffolding, and self-regulated learning.

Table 1. Database and Number of Initial Articles

Database	Articles	Remarks
Scopus	128	International articles indexed with a focus on education, psychology, and learning technology
ScienceDirect	84	Articles from Elsevier journals relevant to education, psychology, and artificial intelligence
SpringerLink	56	Articles from the journal Springer related to learning sciences, psychology, and educational technology
Total	268	The initial number of articles before the PRISMA deduplication and selection process

Table 2. Search Keywords

Components	Keywords
ChatGPT/ GenAI	“ChatGPT” OR “generative AI” OR “generative artificial intelligence” OR “large language model” OR “LLM” OR “AI chatbot”
Scaffolding	“scaffolding” OR “learning support” OR “feedback” OR “pedagogical support” OR “academic support”
SRL	“self-regulated learning” OR “self-regulation” OR “metacognition” OR “metacognitive regulation” OR “learner autonomy”
Population	“student” OR “students” OR “learner” OR “learners” OR “undergraduate” OR “higher education”

PICCO Framework

The article selection criteria were developed using the PICCO framework to guide the research more effectively. This framework is used to determine the population, key interventions or phenomena, comparators, contexts, and outcomes studied.

Table 3. PICCO Framework

Compositions PICCO	Definition in This Study
P – Population	Students, college students, or learners in the context of formal education
I – Interest/ Intervention	The use of ChatGPT, generative AI, a large language model, or an AI chatbot as a scaffolding tool in learning
C – Comparison	Learning without ChatGPT, traditional learning, teacher/lecturer/tutor feedback, other AI tools, or studies without peer groups
C – Context	Educational psychology, online learning, academic writing, EFL learning, programming education, feedback, metacognition, and learning engagement
O – Outcome	Self-regulated learning and related dimensions, such as planning, monitoring, feedback use, help-seeking, self-reflection, self-evaluation, motivation regulation, and learner autonomy

Based on the PICCO, the main question of this review is: How does ChatGPT function as a scaffolding tool in supporting self-regulated student learning?

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria are used to ensure that the articles analyzed align with the research focus and are relevant to ChatGPT, scaffolding, and self-regulated learning.

Table 4. Inclusion and Exclusion Criteria

Aspects	Criteria Inclusion	Exclusion Criteria
Year of publication	Articles published in 2023–2025	Articles before 2023 or after 2025
Language	English articles	Articles other than English
Database	Articles from Scopus, ScienceDirect, and SpringerLink	Articles outside the database are used
Document type	Journal articles or scientific conference papers	Editorials, opinions, book reviews, blogs, and non-academic reports
Focus topic	Discuss ChatGPT, GenAI, LLM, or AI chatbots in learning	Discussing AI in general, unrelated to learning
Populasi	Students, Students, or Learners	Teachers, lecturers, workers, or non-learner populations are the main focus.
Field of study	Educational psychology, SRL, metacognition, motivation, feedback, learner autonomy	Pure technology articles that have nothing to do with the psychological process of learning
Outcome	Discuss SRL or related dimensions.	It does not discuss SRL, metacognition, reflection, the use of feedback, or learner autonomy.
Access articles	Full text available	Full text is not available or cannot be analyzed

Article Selection Procedure Based on PRISMA

The article selection process is carried out in four main stages: identification, screening, eligibility, and inclusion. In the initial stage, 268 articles were obtained from three databases. After the duplicates were removed, a total of 232 articles proceeded to the screening stage. At the screening stage, articles are selected based on title, abstract, keywords, year of publication, language, and document type. A total of 158 articles were excluded because they did not align with the research focus. Furthermore, as many as 74 articles were assessed for eligibility by reading their full texts. After the eligibility assessment, as many as 50 articles were excluded for failing to meet the PISCO criteria. Thus, 24 final articles were obtained and analyzed in the SLR synthesis.

Table 5. Article Selection Flow Based on PRISMA

PRISMA Stage	Articles	Remarks
Identification	268	Initial articles were found through searches on Scopus, ScienceDirect, and SpringerLink.
Duplicate removal	36	Duplicate articles are removed based on similarity in the title, DOI, and metadata of the publication.
Records after duplicate removal	232	Articles left after deduplication
Screening	232	Articles are filtered by title, abstract, keyword, year, language, and document type.
Records excluded	158	The article was removed because it did not fit the focus of ChatGPT/GenAI, SRL, or educational psychology.

PRISMA Stage	Articles	Remarks
Eligibility	74	Full-text articles are assessed using the PICCO framework and their relevance to self-regulated learning.
Full-text articles excluded	50	Articles excluded because they do not meet the inclusion criteria
Included	24	Final article that meets the inclusion criteria and is analyzed in SLR synthesis

Data Analysis and Synthesis

The data were analyzed using a thematic synthesis approach. The synthesis process is carried out by reading the main findings of each article, coding ChatGPT's form of support for the learning process, and then grouping the code into main themes. The themes used in the synthesis include metacognitive scaffolding, feedback scaffolding, reflective scaffolding, motivational scaffolding, collaborative scaffolding, and AI literacy-based scaffolding. Furthermore, these themes are mapped into the dimensions of self-regulated learning, such as planning, monitoring, strategy use, feedback use, help-seeking, self-reflection, and self-evaluation.

RESULTS AND DISCUSSION

Results

Article Selection Results

An article search through the Scopus, ScienceDirect, and SpringerLink databases yielded 268 articles in the early stages. After checking for duplicates, 36 articles were issued, leaving 232 for the screening stage. At the screening stage, articles were selected based on title, abstract, keywords, year of publication, language, document type, and initial suitability with ChatGPT/GenAI topics, scaffolding, and self-regulated learning. At the screening stage, as many as 158 articles were excluded because they did not align with the research focus. A total of 74 articles were then assessed through reading the full text. After the assessment using the PISCO framework, 50 articles were excluded because they did not explicitly discuss SRL, did not focus on students, or were not relevant to the context of educational psychology. Thus, 24 articles met the inclusion criteria and were analyzed in the final synthesis.

A total of 24 articles were analyzed in the 2023–2025 range. Articles in 2025 are the most dominant, with 12, followed by 8 in 2024 and 4 in 2023. This shows an increase in attention to the use of ChatGPT/GenAI for learning after this technology became widely used in education. The dominance of articles in 2025 indicates that research on ChatGPT and SRL is growing rapidly. Scopus (N=11) was the source of the most articles, but ScienceDirect (N=8) and SpringerLink (N=5) also significantly expanded the study's scope.

Selected Article Data Extraction Table

Table 6 presents a summary of the article that best aligns with the research's focus: the use of ChatGPT/GenAI/LLM as a scaffolding tool to support self-regulated learning.

Table 6. Selected Article Data Extraction

No	Author & Year	Research Focus/ Context	Design/Method	Participants	AI/ChatGPT Used	Relevant SRL Dimensions	Reasons for Entering the Main Synthesis
1	Jiang & Xu, 2026	GenAI, metacognitive prompting, anxiety, and self-efficacy	Randomized controlled experiment	148 students	ChatGPT/GenAI	Metacognitive engagement, monitoring, evaluation, and self-efficacy regulation	It is particularly relevant because it tests the use of metacognitive prompting as an SRL scaffold.
2	Hilliger et al., 2026	GAI-based chatbot for scaffolding SRL	Design-based research	276 students, 10 courses	ChatGPT API-based chatbot	Goal setting, planning, task execution, and self-reflection	The core article is because it explicitly discusses the GAI chatbot as an SRL scaffold.
3	Hasanein & Al-Romeedy, 2026	ChatGPT-assisted learning, SRL, and academic achievement	Quantitative survey; PLS-SEM	689 students	ChatGPT	Autonomous learning, planning, monitoring, and self-evaluation	It is relevant because it connects ChatGPT's effectiveness with SRL and achievement.
4	Nguyen & Doan, 2025	ChatGPT-facilitated PBL for autonomy and self-efficacy	Mixed-methods; pretest-posttest	50 EFL learners	ChatGPT	Learner autonomy, self-efficacy, planning, and reflection	Enter because ChatGPT is positioned as a project-based SRL facilitator.
5	Scheu et al., 2026	Mobile chatbot-based learning journaling	Randomized field experiment	179 students	LLM-based journaling assistant	Self-reflection, monitoring, engagement, and motivation regulation	Relevant for reflective scaffolding and SRL-based journaling.
6	Alsaiani et al., 2026	Perbandingan directive, metacognitive, and hybrid AI feedback	Semester-long RCT	329 students	AI-generated feedback	Self-monitoring, revision, feedback use, and confidence regulation	It is relevant because it compares the types of AI feedback to support learning regulation.

No	Author & Year	Research Focus/ Context	Design/Method	Participants	AI/ChatGPT Used	Relevant SRL Dimensions	Reasons for Entering the Main Synthesis
7	Choi et al., 2025	ChatGPT Study Mode in game-based Python learning	Qualitative study	25 elementary school students	ChatGPT Study Mode	Goal setting, self-checking, help-seeking, and strategy adjustment	Enter because ChatGPT acts as a Socratic/hint-based scaffold.
8	Fütterer et al., 2026	GenAI support for SRL school students	Randomized controlled trial	371 students in grades 7–9	GPT-4o-powered systems	Utility value, strategy use, interest, effort	Relevant for motivational and strategic scaffolding.
9	Younis, 2024	ChatGPT in an online learning environment	Quasi-experimental	100 students	ChatGPT in Moodle	Self-regulation, confidence, usefulness, collaborative regulation	It is relevant because it compares individual, peer, and group learning with ChatGPT.
10	Tao et al., 2026	GenAI agent in immersive VR English-speaking task	Randomized experimental study	71 students	GPT-4o agent	Planning, help-seeking, monitoring, adaptation, reflection	Strong because it uses behavioral sequence analysis for SRL patterns.
11	Sun et al., 2026	ChatGPT for academic writing in Chinese as a Second Language	Qualitative study	17 international students	ChatGPT/Poe	Forethought, monitoring, revision, self-evaluation	Relevant for writing SRL based on the three phases of learning regulation.
12	Xu, 2026	GenAI, intention to use, engagement, and SRL EFL	SEM; chain mediation	386 EFL students	ChatGPT, DeepSeek, GenAI tools	Intention, engagement, goal setting, monitoring, and reflection	It is relevant because it explains the mechanism of GenAI towards SRL through engagement.
13	Gao et al., 2026	SRL sequences in a Gen AI-based	Learning analytics;	110 students	ChatGPT is integrated into Ask AI	Goal setting, execution, evaluation, help-	It is relevant because it analyzes the pattern of

No	Author & Year	Research Focus/ Context	Design/Method	Participants	AI/ChatGPT Used	Relevant SRL Dimensions	Reasons for Entering the Main Synthesis
		intelligent tutoring system	sequential analysis			seeking, and reflection	SRL sequences based on trace data.
14	Dolgikh et al., 2026	LLM and SRL in essay-writing tutoring	Within-subject classroom pilot	50 students	GPT-4.1 Virtual Tutor	Planning, monitoring, rubric-based evaluation, and reflection	Relevant for SRL-informed writing tutors.
15	El Hosayny et al., 2026	Metacognitive regulation and ChatGPT-assisted writing	Qualitative, reflexive thematic analysis	25 postgraduate students	ChatGPT	Planning, monitoring, evaluating, information management, and debugging	Core article for metacognitive regulation in ChatGPT-assisted writing.
16	Xuan et al., 2026	Model GAI-assisted EFL writing	Three-cycle action research	31, 33, and 45 cross-cycle students	GAI chatbots include ChatGPT	Pre-writing, feedback use, reflection, and authorship regulation	Relevant because it develops direct and indirect AI assistance models.
17	Yang et al., 2026	LLM + Explainable AI for SRL programming	Quasi-experimental; learning analytics	83 students	GPT-4 + SHAP/XAI	Planning, monitoring, help-seeking, and strategy adjustment	It is relevant because data-driven personal feedback enhances SRL strategies.
18	Yilmaz et al., 2026	GenAI feedback and SRL online higher education	Mixed-methods; quasi-experimental	46 students	ChatGPT-4/OpenAI API	Goal setting, task strategies, time management, help-seeking, and self-evaluation	Core article for learning analytics-based scaffolding feedback.
19	Fan & Gao, 2026	AI-mediated metacognitive intervention in EFL writing	Cross-sectional; PLS-SEM; essay analytics	448 students	Generative AI writing tools	Metacognitive monitoring, feedback	It is relevant because it tests the relationship between AI, metacognitive

No	Author & Year	Research Focus/ Context	Design/Method	Participants	AI/ChatGPT Used	Relevant SRL Dimensions	Reasons for Entering the Main Synthesis
						engagement, and regulation	regulation, and the quality of objective writing.
20	Uzun et al., 2026	GenAI assistant in the learning analytics dashboard	Conversation analysis; ENA	34 students; 22 active users	GPT-4/OpenAI API	Feedback interpretation, monitoring, help-seeking, and strategy formulation	It is relevant because it analyses student dialogue with GenAI according to the SRL level.
21	Kaya & Yildiz Durak, 2026	ChatGPT-mediated mathematical modeling and shared regulation	Qualitative exploratory; Delphi	40 preservice mathematics teachers	ChatGPT-4o	Shared planning, joint monitoring, collaborative evaluation	Relevant for socially shared regulation and collaborative scaffolding.
22	Qin et al., 2026	LLM-based epistemic emotion support in video learning	Controlled within-subjects user study	32 students	LLM-based Epimopilot	Emotional regulation, persistence, monitoring, engagement	Relevant for affective and metacognitive scaffolding.
23	Nieto-Cárdenas et al., 2026	Owlgorithm for SRL in competitive programming	Design and exploratory evaluation	Competitive Programming Students	GPT-4o	Self-reflection, debugging, self-explanation, strategy adjustment	Relevant for LLM-driven reflection scaffolding.
24	Sharma et al., 2026	Hybrid LLM dialogue agent for learner reflection	Exploratory design study	9 middle-school learners	LLaMA-based dialogue system	Goal reflection, planning, monitoring, affective reflection	Relevant for theory-driven reflective scaffolding.

Shape of ChatGPT Scaffolding in SRL

ChatGPT/GenAI supports self-regulated learning through various forms of scaffolding, namely metacognitive, feedback, reflective, motivational-affective, collaborative, and AI literacy-based scaffolding. The most powerful forms of scaffolding are metacognitive scaffolding and writing-process scaffolding, as both are directly related to students' ability to plan, monitor, evaluate, revise, and adjust their learning strategies. These findings confirm that ChatGPT/GenAI is more effective when used as a reflective learning partner, rather than just a tool for obtaining quick answers. In addition, the success of using ChatGPT/GenAI in SRL depends heavily on students' ability to verify information, uphold academic ethics, and maintain independent thinking.

Table 7. Forms of ChatGPT/GenAI Scaffolding in SRL

Scaffolding Shape	Main Functions	Supported SRL Dimensions	Supporting Articles
Metacognitive scaffolding	Help students plan, monitor, evaluate, and improve learning strategies	Planning, monitoring, evaluating, debugging, and strategy adjustment	El Hosayny et al. (2026); Fan & Gao (2026); Jiang and Xu (2026); Tao et al. (2026); Xu (2026)
Feedback scaffolding	Provide fast, personalized, and data-driven feedback learning	Feedback use, task strategies, self-evaluation, help-seeking	Yilmaz et al. (2026); Yang et al. (2026); Alsaiani et al. (2026); Gao et al. (2026)
Reflective-dialogic scaffolding	Encourage reflective dialogue, Socratic questioning, and sense-making of the learning process.	Reflection, self-explanation, and metacognitive awareness	Hilliger et al. (2026); Uzun et al. (2026); Nieto-Cardenas et al. (2026); Scheu et al. (2026)
Writing-process scaffolding	Supports the writing process from brainstorming to revision	Goal setting, outlining, monitoring, revision, source checking	El Hosayny et al. (2026); Xuan et al. (2026); Sun et al. (2026); Dolgikh et al. (2026); Fan & Gao (2026)
Motivational-affective scaffolding	Supports motivation, competence, engagement, and anxiety reduction	Motivation, regulation, persistence, confidence, and emotional regulation	Xu (2026); Schweder et al. (2026); Fan et al. (2025); Fütterer et al. (2026); Qin et al. (2026)
Collaborative/shared regulation scaffolding	Supporting group learning regulation, peer learning, and collaborative discussions	Shared planning, joint monitoring, group reflection, collaborative evaluation	Younis (2024); Kaya & Yildiz Durak (2026); Nguyen & Doan (2025)
AI literacy and verification scaffolding	Helping students use AI critically, ethically, and responsibly	Critical verification, ethical regulation, source checking, agency	Bećirović et al. (2026); El Hosayny et al. (2026); Zheng & Wang (2026); Amzalag et al. (2026)

ChatGPT-Supported SRL Dimensions

ChatGPT supports various dimensions of self-regulated learning, especially planning, monitoring, use of feedback, help-seeking, self-evaluation, reflection, strategy adjustment, and motivation regulation. This support can be mapped to three main phases of SRL: forethought, performance, and self-reflection. In the forethought phase, ChatGPT helps students understand assignments, set goals, make plans, and choose learning strategies. In the performance phase, ChatGPT helps students monitor comprehension, seek help, use feedback, and adjust strategies when facing difficulties. In the self-reflection phase, ChatGPT helps students evaluate learning outcomes, reflect on mistakes, improve strategies, and design next steps for improvement. Thus, ChatGPT's support is most evident in the performance and self-reflection phases, as it is widely used when students are working on assignments, seeking feedback, revising, and evaluating the quality of their learning outcomes.

Table 8. SRL Dimension Mapping and ChatGPT Support

SRL Phase	Forms of ChatGPT/GenAI Support	Examples of Student Activities	Supporting Articles
Forethought	Goal setting, task analysis, brainstorming, planning	Compiling learning objectives, outlining writing, choosing a learning strategy, and understanding assignment instructions	El Hosayny et al. (2026); Sun et al. (2026); Choi et al. (2025); Hilliger et al. (2026)
Performance	Monitoring, feedback use, help-seeking, strategy implementation	Check grammar, check code, ask for feedback, compare AI answers to rubrics	Yilmaz et al. (2026); Yang et al. (2026); Gao et al. (2026); Fan & Gao (2026)
Self-reflection	Self-evaluation, reflective dialogue, debugging, and revision planning	Evaluate AI output, fix prompts, revise writing, and perform source checking	Uzun et al. (2026); Scheu et al. (2026); Nieto-Cardenas et al. (2026); Xuan et al. (2026)
Motivational regulation	Encouragement, confidence, support, and anxiety reduction	Reduce fear of wrongdoing, increase ability, maintain interest in learning	Xu (2026); Fan et al. (2025); Schweder et al. (2026); Fütterer et al. (2026)
Collaborative regulation	Peer discussion, group reflection, shared monitoring	Discussing ChatGPT output, dividing roles, and evaluating group results	Nguyen & Doan (2025); Younis (2024); Kaya & Yildiz Durak (2026)

Learning Outcomes from Using ChatGPT

The use of ChatGPT/GenAI in the analyzed articles shows a major contribution to strengthening the self-regulated learning process, not solely to improving final performance. ChatGPT/GenAI helps students develop task strategies, metacognitive engagement, feedback engagement, learner autonomy, motivation, confidence, and reflection. In the context of writing, AI supports students from the stage of idea planning, drafting, revision, and evaluation of writing quality. In the context of programming, AI supports debugging, self-explanation, and strategy adjustment, helping students understand mistakes and improve their problem-solving strategies.

These findings suggest that the benefits of ChatGPT/GenAI are stronger when used as a reflective and feedback-based tool. Thus, ChatGPT/GenAI is more appropriately understood as a scaffolding tool that supports the learning process in an adaptive, critical, and regulatory manner, rather than as a direct determinant of learning outcomes.

Table 9. Learning Outcomes from Using ChatGPT/GenAI

Outcome	Pattern of Findings	Supporting Articles
Increased task strategies	GenAI feedback helps students choose and improve their learning strategies.	Yilmaz et al. (2026); Yang et al. (2026); Gao et al. (2026)
Increased metacognitive engagement	Reflective prompts and metacognitive strategies help students monitor and evaluate the learning process.	Jiang & Xu (2026); EL Hosayny et al. (2026); Fan & Gao (2026)
Increased learner autonomy	ChatGPT supports learning decisions, agency, and independence in project-based learning.	Nguyen & Doan (2025); Hasanein & Al-Romeedy (2026); Younis (2024)
Writing quality increased	AI-mediated strategy use and feedback engagement related to textual accuracy, lexical sophistication, and cohesion	Fan & Gao (2026). Xuan et al. (2026); Sun et al. (2026); Dolgikh et al. (2026)
Improved programming performance	LLM/XAI and AI-assisted programming support debugging, self-explanation, and strategy adjustment	Yang et al. (2026); Choi et al. (2025); Nieto-Cardenas et al. (2026)
Increased motivation and confidence	GenAI supports competence satisfaction, engagement, and lowers anxiety	Xu (2026); Schweder et al. (2026); Fan et al. (2025); Fütterer et al. (2026)
Increased Reflection	LLM can close the gap of reflection through journaling, Socratic dialogue, and reflective inquiry	Scheu et al. (2026); Hilliger et al. (2026); Nieto-Cardenas et al. (2026); Uzun et al. (2026)

Challenges of Using ChatGPT in SRL

The use of ChatGPT/GenAI in self-regulated learning still poses several challenges that need to be anticipated. The most prominent challenge is over-reliance and superficial use, the tendency for students to use AI excessively or to seek quick answers without engaging in deep thinking. This condition can weaken learner agency, cognitive efforts, monitoring, and self-reflection. In addition, the risk of hallucination requires students to verify sources and conduct critical analysis so they do not passively accept AI-generated information. The limitations of personalization and social presence also show that ChatGPT is not yet fully capable of replacing the role of lecturers, peers, and learning communities in providing contextual and emotional support. Therefore, the use of ChatGPT/GenAI needs to be guided by a learning design that emphasizes AI literacy, academic ethics, critical verification, and reflection, so that AI really functions as a scaffolding tool that strengthens SRL, rather than creating a learning dependency.

Table 8. Challenges of Using ChatGPT/GenAI in SRL

Challenge	Explanation	Implications for SRL	Supporting Articles
Over-reliance	College students rely too much on AI to complete assignments	Reduce learner agency and cognitive effort	EL Hosayny et al. (2026); Zheng & Wang (2026); Gao et al. (2026); Hilliger et al. (2026)

Challenge	Explanation	Implications for SRL	Supporting Articles
Superficial use	AI is only used to search for information or improve grammar	Not encouraging in-depth monitoring and reflection	Gao et al. (2026); Fan & Gao (2026); Xuan et al. (2026)
Hallucination	AI generates inaccurate or unverifiable information	Requires source checking and critical verification	El Hosayny et al. (2026); Xuan et al. (2026); Nieto-Cárdenas et al. (2026)
Weak personalization	Feedback AI is not yet fully adaptive to the learning context of students	Reduce the actionability and relevance of feedback	Uzun et al. (2026); Yilmaz et al. (2026)
Limited relatedness	AI has not replaced human social relationships and emotional support	SRL still needs the support of teachers, friends, and the learning community	Schweder et al. (2026); Fan et al. (2025); Nguyen & Doan (2025)
Ethical concerns	Plagiarism, authorship, and academic integrity	Requires AI literacy and ethical regulation	Bećirović et al. (2026); El Hosayny et al. (2026); Xuan et al. (2026)

Discussion

ChatGPT/GenAI can be understood as a form of digital scaffolding that extends the concept of learning assistance within social constructivism. From Vygotsky's (1978) perspective, the learning process unfolds through external support that helps learners move from actual to potential abilities. This idea is reinforced by Wood et al. (1976), who explain that scaffolding simplifies tasks, maintains focus on learning, and helps learners achieve goals gradually. In the context of GenAI, this function appears when ChatGPT provides directions, reflective questions, examples, feedback, and alternative learning strategies. The findings of Ng et al. (2024), Lee et al. (2024), Wu et al. (2024), and Li (2023) show that ChatGPT can support self-regulated learning, knowledge construction, and learning performance when its use is directed through clear guidance mechanisms.

The role of ChatGPT/GenAI in self-regulated learning can be explained through Zimmerman's (2000, 2002) cyclical model, which includes the forethought, performance, and self-reflection phases. In the forethought phase, ChatGPT helps learners understand the task's requirements, set goals, and choose a learning strategy. In the performance phase, ChatGPT supports monitoring, help-seeking, feedback use, and strategy adjustment when students face difficulties. In the self-reflection phase, ChatGPT helps students evaluate results, identify weaknesses, and design improvement steps. This view is in line with Prasad and Sane (2024), Lai (2024), Tomisu et al. (2025), and Lim et al. (2025), who emphasize that GenAI has the potential to strengthen learning regulations when used as a reflection tool, not as a substitute for students' thinking processes.

The most prominent form of scaffolding is metacognitive scaffolding. Theoretically, metacognition includes the ability to plan, monitor, control, and evaluate one's own thought processes (Flavell, 1979; Pintrich, 2004). ChatGPT/GenAI can support this aspect through reflective prompts, concept clarification, guiding questions, answer evaluation, and learning

strategy recommendations. Neshaei et al. (2025) show that LLMs can reinforce reflective writing through metacognitive processes, while Tankelevitch et al. (2024) assert that interaction with GenAI requires users to design prompts, evaluate responses, and control the flow of thought. The findings of Lee et al. (2024), Wu et al. (2024), Weng et al. (2024), and Wang (2024) also show that the use of GenAI is related to students' ability to strategize, build understanding, and conduct self-evaluation. However, this metacognitive support is only meaningful if students remain active in assessing AI output.

In addition to metacognitive scaffolding, feedback scaffolding is an important form of support in the use of ChatGPT/GenAI. Feedback theory emphasizes that effective feedback not only provides information about whether something is true or false but also helps learners understand learning objectives, current achievement levels, and next steps for improvement (Hattie & Timperley, 2007). Nicol and Macfarlane-Dick (2006) also emphasized that good feedback should strengthen self-regulation. In this context, AI-generated feedback can help students revise, improve strategies, and increase engagement with the learning process. Banihashem et al. (2024), Meyer et al. (2024), Weidlich et al. (2025), Sun et al. (2025), Ba et al. (2025), and Jin et al. (2025) show that AI-based feedback contributes to writing revision, literacy feedback, task strategies, and learning engagement. However, the effectiveness of AI feedback depends heavily on learners' ability to understand, verify, and act on it.

In the context of academic writing, ChatGPT/GenAI aligns with process writing theory, which views writing as a recursive process involving planning, drafting, revising, and evaluating. Flower and Hayes (1981) explain that writing is not a linear activity, but rather a cognitive process that involves continuous problem-solving. ChatGPT can help students brainstorm, outline, revise, paraphrase, and self-evaluate. Wang (2024), Neshaei et al. (2025), Yang et al. (2025), Tran (2025), Oktarin et al. (2024), Werdiningsih et al. (2024), and Khampusaen (2025) show that the use of ChatGPT/GenAI in academic writing can support revision, feedback literacy, self-efficacy, and writing quality. However, AI still needs to be positioned as a partner for reflection and revision, not as a substitute for student authorship or intellectual responsibility.

ChatGPT/GenAI's support for motivation, learner autonomy, and self-efficacy can be explained through self-determination theory and social cognitive theory. Deci and Ryan (2000) explain that motivation develops when the needs of autonomy, competence, and relatedness are met. ChatGPT can support autonomy by giving students the flexibility to determine how they learn, and support competence through feedback and responsive explanations. In Bandura's (1997) perspective, self-efficacy develops through success experiences, social support, and management of affective conditions. Lai et al. (2023), Nguyen and Doan (2025), Kittredge et al. (2025), Meyer et al. (2024), Huang et al. (2024), and Cheung et al. (2025) show that the use of ChatGPT/GenAI is related to motivation, self-efficacy, learner autonomy, well-being, and independent learning disposition. Nonetheless, the relatedness aspect remains a limitation, as human emotional connection, empathy, and social support cannot be fully replaced by AI.

ChatGPT/GenAI also has relevance to the socially shared regulation of learning, especially when used in collaborative learning. Hadwin et al. (2018) explained that learning regulation does not only occur at the individual level but also at the group level through joint planning, monitoring, and evaluation. In this context, ChatGPT can help learning groups structure ideas, compare arguments, clarify concepts, and generate reflective questions. Ortiz et al. (2024), Lu et al. (2025), Pahi et al. (2024), Dang et al. (2025), and Yan et al. (2025) show that GenAI can support peer feedback, shared metacognition, engagement, collaborative learning, and understanding of learning analytics. However, the collaborative function of AI is only effective when it is used to

strengthen interaction between learners, rather than replacing discussion, negotiation of meaning, and group learning responsibilities.

Despite its great potential, the use of ChatGPT/GenAI in SRL also presents challenges that warrant critical examination. Major risks include over-reliance, superficial use, hallucinations, limited personalization, weak social presence, and academic ethical issues. This risk can be explained by the concept of cognitive offloading, in which students transfer part of their cognitive load to external tools. Cognitive offloading can improve learning efficiency, but it can also undermine knowledge internalization if learners rely too heavily on AI. Fan et al. (2025) refer to this condition as metacognitive laziness, while Tankelevitch et al. (2024), Wang et al. (2025), Hooshyar et al. (2025), and Viberg et al. (2025) emphasize the importance of human agency, metacognitive control, and responsible AI in education. Thus, ChatGPT can strengthen SRL by encouraging students to think critically, but it can weaken SRL if it is used only as a shortcut for completing tasks.

Other no-less-important challenges include AI literacy, feedback literacy, and academic integrity. In AI-based learning, learners need to understand how AI works, evaluate the accuracy of responses, verify sources, and use AI output ethically. Anders and Dux Speltz (2025), Delcker et al. (2024), Chuah and Sumintono (2024), Jin et al. (2025), McPhee and Jerowsky (2025), and Nguyen et al. (2025) emphasize that the integration of GenAI in learning must be accompanied by literacy, readiness, and clear assessment guidelines. This shows that the success of ChatGPT/GenAI as a scaffolding tool is not determined solely by technological sophistication but also by the quality of pedagogical design, student readiness, the role of lecturers, and the academic norms governing its use.

Overall, ChatGPT/GenAI is better understood as a pedagogically guided scaffolding tool for self-regulated learning. AI can support learners in planning, monitoring, seeking help, using feedback, reflecting, and improving their learning strategies. However, AI does not automatically improve SRL unless clear learning designs, reflective prompts, rubrics, information verification, and self-evaluation guide its use. Makransky et al. (2025), Steinert et al. (2024), Prasad and Sane (2024), Lee et al. (2024), and Tomisu et al. (2025) affirm that GenAI is most beneficial when used to build sense-making, metacognition, and self-regulation. Therefore, integrating ChatGPT/GenAI into learning should prioritize learner agency, AI literacy, feedback literacy, and academic integrity as core principles, ensuring this technology truly strengthens students' independence, reflection, and learning responsibility.

CONCLUSION

ChatGPT/GenAI can be understood as a scaffolding tool that can strengthen students' self-regulated learning by supporting the planning of learning objectives, understanding tasks, monitoring the learning process, seeking help, using feedback, reflecting, self-evaluating, and adjusting learning strategies. The role of ChatGPT/GenAI is not limited to being an information provider; it also serves as a reflective learning partner that can help students develop metacognitive engagement, feedback engagement, learner autonomy, motivation, self-efficacy, and the quality of learning performance when used in a directed manner. However, the use of this technology must be accompanied by a clear learning design to avoid encouraging dependency, superficial use, plagiarism, or passive acceptance of AI output. Therefore, lecturers and educational institutions need to integrate ChatGPT/GenAI with pedagogical guidance, AI literacy, academic ethics, information verification, feedback literacy, and reflective activities. The next research is suggested to test the effectiveness of ChatGPT/GenAI through experimental, longitudinal, or mixed-methods

designs, while considering variations across fields of study, education levels, student readiness, lecturer roles, and mechanisms for how AI can strengthen students' independence in learning without replacing students' critical thinking processes.

REFERENCES

- Anders, A. D., & Dux Speltz, E. (2025). Developing generative AI literacies through self-regulated learning: A human-centered approach. *Computers and Education: Artificial Intelligence*, 9, Article 100482. <https://doi.org/10.1016/j.caeai.2025.100482>
- Ba, S., Yang, L., Yan, Z., Looi, C. K., & Gašević, D. (2025). Unraveling the mechanisms and effectiveness of AI-assisted feedback in education: A systematic literature review. *Computers and Education Open*, 9, Article 100284. <https://doi.org/10.1016/j.caeo.2025.100284>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.
- Banihashem, S. K., Kerman, N. T., Noroozi, O., Moon, J., & Drachsler, H. (2024). Feedback sources in essay writing: Peer-generated or AI-generated feedback? *International Journal of Educational Technology in Higher Education*, 21(1), Article 23. <https://doi.org/10.1186/s41239-024-00455-4>
- Cheung, L. M. E., Lo, O.-T., & Shi, H. (2025). Exploring the relationships among perceived AI ability, academic self-efficacy, and independent learning disposition in the tertiary contexts. *Computers and Education: Artificial Intelligence*, 9, Article 100516. <https://doi.org/10.1016/j.caeai.2025.100516>
- Chuah, K.-M., & Sumintono, B. (2024). University student readiness and academic integrity in using ChatGPT and AI tools for assessments. In *Lecture Notes in Educational Technology* (pp. 69–88). Springer. https://doi.org/10.1007/978-981-97-6136-4_4
- Dang, B., Huynh, L., Gul, F., Rosé, C., Järvelä, S., & Nguyen, A. (2025). Human–AI collaborative learning in mixed reality: Examining the cognitive and socio-emotional interactions. *British Journal of Educational Technology*, 56(5), 2078–2101. <https://doi.org/10.1111/bjet.13607>
- Deci, E. L., & Ryan, R. M. (2000). The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01
- Delcker, J., Heil, J., Ifenthaler, D., Seufert, S., & Spirgi, L. (2024). First-year students AI-competence as a predictor for intended and de facto use of AI-tools for supporting learning processes in higher education. *International Journal of Educational Technology in Higher Education*, 21(1), Article 18. <https://doi.org/10.1186/s41239-024-00452-7>
- Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X., & Gašević, D. (2025). Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology*, 56(2), 489–530. <https://doi.org/10.1111/bjet.13544>
- Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*, 34(10), 906–911. <https://doi.org/10.1037/0003-066X.34.10.906>
- Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, 32(4), 365–387. <https://doi.org/10.2307/356600>
- Hadwin, A. F., Järvelä, S., & Miller, M. (2018). Self-regulation, co-regulation, and shared regulation in collaborative learning environments. In D. H. Schunk & J. A. Greene (Eds.), *Handbook of self-regulation of learning and performance* (2nd ed., pp. 83–106). Routledge.

- Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77(1), 81–112. <https://doi.org/10.3102/003465430298487>
- Hooshyar, D., Šir, G., Yang, Y., Kikas, E., Hämäläinen, R., Kärkkäinen, T., Gašević, D., & Azevedo, R. (2025). Towards responsible AI for education: Hybrid human-AI to confront the elephant in the room. *Computers and Education: Artificial Intelligence*, 9, Article 100524. <https://doi.org/10.1016/j.caeai.2025.100524>
- Huang, F., Wang, Y., & Zhang, H. (2024). Modelling generative AI acceptance, perceived teachers' enthusiasm and self-efficacy to English as a foreign language learners' well-being in the digital era. *European Journal of Education*, 59(4), Article e12770. <https://doi.org/10.1111/ejed.12770>
- Jin, F. J.-Y., Maheshi, B., Lai, W., Li, Y., Gasevic, D., Chen, G., Charwat, N., Chan, P. W. K., Martinez-Maldonado, R., Gašević, D., & Tsai, Y.-S. (2025). Students' perceptions of generative AI-powered learning analytics in the feedback process: A feedback literacy perspective. *Journal of Learning Analytics*, 12(1), 152–168. <https://doi.org/10.18608/jla.2025.8609>
- Khampusaen, D. (2025). The impact of ChatGPT on academic writing skills and knowledge: An investigation of its use in argumentative essays. *LEARN Journal: Language Education and Acquisition Research Network*, 18(1), 963–988. <https://doi.org/10.70730/PGCQ9242>
- Kittredge, A. K., Hopman, E. W. M., Reuveni, B., Dionne, D., Freeman, C., & Jiang, X. (2025). Mobile language app learners' self-efficacy increases after using generative AI. *Frontiers in Education*, 10, Article 1499497. <https://doi.org/10.3389/feduc.2025.1499497>
- Lai, C. Y., Cheung, K. Y., & Chan, C. S. (2023). Exploring the role of intrinsic motivation in ChatGPT adoption to support active learning: An extension of the technology acceptance model. *Computers and Education: Artificial Intelligence*, 5, Article 100178. <https://doi.org/10.1016/j.caeai.2023.100178>
- Lai, J. W. (2024). Adapting self-regulated learning in an age of generative artificial intelligence chatbots. *Future Internet*, 16(6), Article 218. <https://doi.org/10.3390/fi16060218>
- Lee, H.-Y., Chen, P.-H., Wang, W.-S., Huang, Y.-M., & Wu, T.-T. (2024). Empowering ChatGPT with guidance mechanism in blended learning: Effect of self-regulated learning, higher-order thinking skills, and knowledge construction. *International Journal of Educational Technology in Higher Education*, 21(1), Article 16. <https://doi.org/10.1186/s41239-024-00447-4>
- Li, H.-F. (2023). Effects of a ChatGPT-based flipped learning guiding approach on learners' courseware project performances and perceptions. *Australasian Journal of Educational Technology*, 39(5), 40–58. <https://doi.org/10.14742/ajet.8923>
- Lim, L.-A., Ainscough, L., Deneen, C., Pacitti, H., Taylor-Griffiths, D., Male, S. A., & Frankland, S. (2025). Transition pedagogy in the age of AI: The role of self-regulated learning. *Student Success*, 16(3 Special Issue), 57–66. <https://doi.org/10.63608/ssj.3766>
- Lu, G., Ba, S., & Yang, L. (2025). Optimizing GAI-assisted formative feedback: An experimental study on its effects on engagement, shared metacognition, and learning performance in online collaborative learning. *Education and Information Technologies*, 30(18), 25937–25967. <https://doi.org/10.1007/s10639-025-13778-0>
- Makransky, G., Shiwalia, B. M., Herlau, T., & Blurton, S. (2025). Beyond the “wow” factor: Using generative AI for increasing generative sense-making. *Educational Psychology Review*, 37(3), Article 60. <https://doi.org/10.1007/s10648-025-10039-x>

- McPhee, S. W., & Jerowsky, M. (2025). Beyond technical skills: A pedagogical perspective on fostering critical engagement with generative AI in university classrooms. *Frontiers in Education*, 10, Article 1593278. <https://doi.org/10.3389/feduc.2025.1593278>
- Meyer, J., Jansen, T., Schiller, R., Liebenow, L. W., Steinbach, M., Horbach, A., & Fleckenstein, J. (2024). Using LLMs to bring evidence-based feedback into the classroom: AI-generated feedback increases secondary students' text revision, motivation, and positive emotions. *Computers and Education: Artificial Intelligence*, 6, Article 100199. <https://doi.org/10.1016/j.caeai.2023.100199>
- Neshaei, S. P., Mejia-Domenzain, P., Davis, R. L., & Käser, T. (2025). Metacognition meets AI: Empowering reflective writing with large language models. *British Journal of Educational Technology*, 56(5), 1864–1896. <https://doi.org/10.1111/bjet.13601>
- Ng, D. T. K., Tan, C. W., & Leung, J. K. L. (2024). Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study. *British Journal of Educational Technology*, 55(4), 1328–1353. <https://doi.org/10.1111/bjet.13454>
- Nguyen, A., Duong, A. T., Nguyen, D. T. B., Lai, V. T. T., & Dang, B. (2025). Guidelines for learning design and assessment for generative artificial intelligence-integrated education: A unified view. *Information and Learning Science*, 126(7–8), 491–512. <https://doi.org/10.1108/ILS-11-2024-0148>
- Nguyen, Q. N., & Doan, D. T. H. (2025). ChatGPT's effects on EFL learners' autonomy and self-efficacy in self-regulated learning contexts. *JALT CALL Journal*, 21(2), Article 102968. <https://doi.org/10.29140/jaltcall.v21n2.102968>
- Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, 31(2), 199–218. <https://doi.org/10.1080/03075070600572090>
- Oktarin, I. B., Saputri, M. E. E., Magdalena, B., Hastomo, T., & Maximilian, A. (2024). Leveraging ChatGPT to enhance students' writing skills, engagement, and feedback literacy. *Edelweiss Applied Science and Technology*, 8(4), 2306–2319. <https://doi.org/10.55214/25768484.v8i4.1600>
- Ortiz, L. G., Maina, M., Lanzo, N. C., & Fernández-Ferrer, M. (2024). Self-regulation of learning from a peer feedback approach: Insights from generative AI. *Revista de Educación a Distancia*, 24(78), Article 2. <https://doi.org/10.6018/red.599511>
- Pahi, K., Hawlader, S., Hicks, E., Zaman, A., & Phan, V. (2024). Enhancing active learning through collaboration between human teachers and generative AI. *Computers and Education Open*, 6, Article 100183. <https://doi.org/10.1016/j.caeo.2024.100183>
- Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review*, 16(4), 385–407. <https://doi.org/10.1007/s10648-004-0006-x>
- Prasad, P., & Sane, A. (2024). A self-regulated learning framework using generative AI and its application in CS educational intervention design. In *SIGCSE 2024: Proceedings of the 55th ACM Technical Symposium on Computer Science Education* (pp. 1070–1076). Association for Computing Machinery. <https://doi.org/10.1145/3626252.3630828>
- Steinert, S., Avila, K. E., Ruzika, S., Kuhn, J., & Küchemann, S. (2024). Harnessing large language models to develop research-based learning assistants for formative feedback. *Smart Learning Environments*, 11(1), Article 62. <https://doi.org/10.1186/s40561-024-00354-1>
- Sun, D., Xu, P., Zhang, J., Liu, R., & Zhang, J. (2025). How self-regulated learning is affected by feedback based on large language models: Data-driven sustainable development in computer

- programming learning. *Electronics*, 14(1), Article 194. <https://doi.org/10.3390/electronics14010194>
- Tankelevitch, L., Kewenig, V., Simkute, A., Scott, A. E., Sarkar, A., Sellen, A., & Rintel, S. (2024). The metacognitive demands and opportunities of generative AI. In *Conference on Human Factors in Computing Systems - Proceedings* (Article 680). Association for Computing Machinery. <https://doi.org/10.1145/3613904.3642902>
- Tomisu, H., Ueda, J., & Yamanaka, T. (2025). The cognitive mirror: A framework for AI-powered metacognition and self-regulated learning. *Frontiers in Education*, 10, Article 1697554. <https://doi.org/10.3389/feduc.2025.1697554>
- Tran, T. T. T. (2025). Enhancing EFL writing revision practices: The impact of AI- and teacher-generated feedback and their sequences. *Education Sciences*, 15(2), Article 232. <https://doi.org/10.3390/educsci15020232>
- Viberg, O., Poquet, O., Kovanovic, V., & Khosravi, H. (2025). Fostering human agency in age of AI: A learning analytics perspective. *Journal of Learning Analytics*, 12(3), 1–7. <https://doi.org/10.18608/jla.2025.9485>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Wang, F., Tang, X., & Yu, S. (2025). Cognitive outsourcing based on generative artificial intelligence: An analysis of interactive behavioral patterns and cognitive structural features. *Acta Psychologica Sinica*, 57(6), 967–986. <https://doi.org/10.3724/SP.J.1041.2025.0967>
- Wang, Y. (2024). Cognitive and sociocultural dynamics of self-regulated use of machine translation and generative AI tools in academic EFL writing. *System*, 126, Article 103505. <https://doi.org/10.1016/j.system.2024.103505>
- Weidlich, J., Gotsch, F., Schudel, K., Marusic-Würscher, C., Mazzarella, J., Bolten, H., Büttler, D., Luger, S., Wohlfender, B., & Merki, K. M. (2025). Teacher, peer, or AI? Comparing effects of feedback sources in higher education. *Computers and Education Open*, 9, Article 100300. <https://doi.org/10.1016/j.caeo.2025.100300>
- Weng, X., Xia, Q., Ahmad, Z., & Chiu, T. K. F. (2024). Personality traits for self-regulated learning with generative artificial intelligence: The case of ChatGPT. *Computers and Education: Artificial Intelligence*, 7, Article 100315. <https://doi.org/10.1016/j.caeai.2024.100315>
- Werdiningsih, I., Indrawati, I., Rusdin, D., Ivone, F. M., & Basthomi, Y. (2024). Revolutionizing EFL writing: Unveiling the strategic use of ChatGPT by Indonesian master's students. *Cogent Education*, 11(1), Article 2399431. <https://doi.org/10.1080/2331186X.2024.2399431>
- Winne, P. H., & Hadwin, A. F. (1998). Studying as self-regulated learning. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 277–304). Lawrence Erlbaum Associates.
- Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 17(2), 89–100. <https://doi.org/10.1111/j.1469-7610.1976.tb00381.x>
- Wu, T.-T., Lee, H.-Y., Li, P.-H., Huang, C.-N., & Huang, Y.-M. (2024). Promoting self-regulation progress and knowledge construction in blended learning via ChatGPT-based learning aid. *Journal of Educational Computing Research*, 61(8), 3–31. <https://doi.org/10.1177/07356331231191125>
- Yan, L., Martinez-Maldonado, R., Jin, Y., Echeverria, V., Milesi, M., Fan, J., Zhao, L., Alfredo, R., Li, X., & Gašević, D. (2025). The effects of generative AI agents and scaffolding on

- enhancing students' comprehension of visual learning analytics. *Computers and Education*, 234, Article 105322. <https://doi.org/10.1016/j.compedu.2025.105322>
- Yang, Y., Hussin, S., & Hashim, H. (2025). Revising with intelligence: ChatGPT feedback and its impact on EFL students' revision and self-efficacy. *Forum for Linguistic Studies*, 7(7), 352–367. <https://doi.org/10.30564/fls.v7i7.9845>
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). Academic Press.
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2