

INPLASY2025110077
doi: 10.37766/inplasy2025.11.0077
Received: 24 November 2025
Published: 25 November 2025

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ADMINISTRATIVE INFORMATION

Support - No specific funding was received for this study.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY2025110077

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 25 November 2025 and was last updated on 25 November 2025.

INTRODUCTION

Review question / Objective Population (P):
Learners in formal education settings, including secondary school and higher education students.
Intervention (I):
The integration and use of Generative Artificial Intelligence (GenAI) tools (e.g., ChatGPT, AI writing assistants, intelligent tutoring systems) to support learning and academic activities.
Comparison (C):
Learners receiving traditional instruction or using non-GenAI-supported learning approaches, or studies without explicit comparison groups.
Outcomes (O):
Self-regulated learning (SRL) outcomes, including cognitive strategies, metacognitive regulation, motivational processes, learning engagement, and academic performance.
Study Design (S):
Empirical studies, including quantitative, qualitative, and mixed-methods research.

Review Question / Objective:
This systematic review aims to investigate how Generative Artificial Intelligence (GenAI) tools are being used to support self-regulated learning (SRL) among students in secondary and higher education settings. Specifically, it seeks to examine the effects of GenAI-assisted learning on students' cognitive, metacognitive, motivational, and behavioral dimensions of self-regulated learning, in comparison to traditional or non-GenAI learning approaches. In addition, this review will synthesise evidence from empirical quantitative, qualitative, and mixed-methods studies to identify instructional designs, learning contexts, and types of GenAI applications that are most conducive to enhancing self-regulated learning capacities. It will also analyse methodological characteristics, research gaps, limitations, and emerging trends in current studies, with the aim of proposing future research directions and pedagogical implications for the effective and ethical integration of Generative AI in self-regulation-oriented learning environments.

Condition being studied The condition being studied in this review is self-regulated learning (SRL) in the context of Generative Artificial Intelligence (GenAI)-supported education. Self-regulated learning refers to learners' capacity to actively plan, monitor, control, and evaluate their cognitive, motivational, emotional, and behavioral processes in order to achieve learning goals. It involves a dynamic cycle of goal setting, strategic planning, self-monitoring, self-reflection, and adaptive regulation, which is crucial for academic success and lifelong learning in complex digital environments.

With the rapid advancement of Generative Artificial Intelligence technologies, such as large language models, AI writing assistants, and intelligent tutoring systems, the learning landscape is undergoing profound transformation. These tools not only provide instant feedback, personalized learning resources, and adaptive support, but also reshape how learners manage their own learning processes. GenAI has the potential to scaffold metacognitive awareness, enhance motivation, support strategic learning behaviors, and promote autonomous learning. However, it also poses risks, such as over-reliance, reduced cognitive effort, and potential erosion of learners' self-regulation if used inappropriately.

This review focuses on understanding how Generative AI tools influence different dimensions of self-regulated learning, including cognitive strategies (e.g., elaboration, rehearsal, organization), metacognitive regulation (e.g., planning, monitoring, evaluation), motivational beliefs (e.g., self-efficacy, goal orientation), and behavioral engagement (e.g., time management, persistence). By synthesizing existing empirical evidence, this study aims to clarify whether and how GenAI contributes to the development of students' self-regulated learning capabilities, to identify critical mechanisms and contextual factors, and to highlight potential risks and challenges. This understanding is essential for guiding the responsible design and implementation of GenAI in education and ensuring that technological innovations genuinely support, rather than undermine, learners' self-regulatory competence.

METHODS

Participant or population Students in secondary and higher education who engage in learning activities supported by Generative Artificial Intelligence tools.

Intervention The intervention of interest is the use of Generative Artificial Intelligence (GenAI) tools to support students' learning processes. This includes AI-powered chatbots, large language models (e.g., ChatGPT), AI writing assistants, and intelligent tutoring systems that are integrated into educational activities to enhance self-regulated learning.

Comparator The comparator includes students exposed to traditional learning approaches or learning environments that do not involve the use of Generative Artificial Intelligence tools.

Study designs to be included Quantitative, qualitative, and mixed-method empirical studies, including randomized controlled trials, quasi-experimental studies, cross-sectional surveys, longitudinal studies, and qualitative research. Reviews, theoretical papers, and commentaries will be excluded.

Eligibility criteria

Inclusion criteria:

Empirical studies published in English.

Studies that explicitly examine the use of Generative Artificial Intelligence tools (e.g., large language models, AI chatbots, AI writing assistants) in educational or learning contexts.

Studies that include clear measures or descriptions of self-regulated learning or its related dimensions (e.g., planning, monitoring, motivation, metacognition, learning strategies).

Studies published between 2000 and 2025.

Exclusion criteria:

Studies focusing on non-generative AI tools or general educational technologies without generative AI features.

Non-empirical publications, including conceptual papers, opinion pieces, editorials, dissertations, conference abstracts, and systematic reviews.

Studies without sufficient methodological details or inaccessible full texts.

Studies not directly related to self-regulated learning (e.g., focusing only on technical performance of AI systems without educational or psychological outcomes).

Studies conducted in non-educational contexts (e.g., corporate training or clinical settings).

Information sources The literature search will be conducted using the following five major electronic databases: Web of Science, Wiley Online Library, EBSCOhost Complete Package, ScienceDirect, and Taylor & Francis Online. These databases were selected due to their extensive coverage of peer-

reviewed journals in education, psychology, learning sciences, and educational technology. A comprehensive search strategy will be developed and adapted for each database by using combinations of controlled vocabulary terms and free-text keywords related to Generative Artificial Intelligence, large language models, AI-supported learning, and self-regulated learning. Search results will be exported into reference management software for screening and duplicate removal.

In addition, the reference lists of all included studies will be manually reviewed to identify potentially relevant articles that were not captured through database searching. Where necessary, corresponding authors will be contacted via email to request missing information or full-text access. Only studies published in English will be considered for inclusion.

Main outcome(s) The primary outcome of this systematic review is self-regulated learning (SRL). SRL will be examined as a multi-dimensional construct, including:

Cognitive and metacognitive regulation, such as planning, monitoring, evaluation, reflection, and strategic learning behaviors.

Motivational components, including learning motivation, self-efficacy, goal orientation, and persistence.

Behavioral engagement, including time management, task completion, and learning autonomy.

Self-regulated learning outcomes will be identified based on validated measurement instruments (e.g., MSLQ, SRL questionnaires, metacognitive awareness inventories), observational data, learning analytics, or qualitative indicators reported in the included studies.

Secondary outcomes will include academic performance, learning engagement, and learning strategy use when these outcomes are explicitly linked to self-regulated learning processes and Generative AI-supported learning.

Effect measures will include quantitative indicators such as correlation coefficients, effect sizes (e.g., Cohen's *d*, standardized mean differences), regression coefficients, and pre-post change scores, as well as qualitative descriptions of changes in learners' self-regulatory behaviors. Where possible, effect direction, magnitude, and consistency across studies will be synthesized. If sufficient homogeneous data are available, a meta-analytic synthesis will be conducted; otherwise, a narrative synthesis will be provided.

No restriction will be placed on timing of outcome measurement due to variability in intervention duration across studies.

Quality assessment / Risk of bias analysis The methodological quality and risk of bias of included studies will be assessed using appropriate standardized tools based on study design. For randomized controlled trials and experimental studies, the Cochrane Risk of Bias tool (RoB 2.0) will be applied to evaluate potential bias across domains including randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of reported results.

For non-randomized quantitative studies, including quasi-experimental, cross-sectional, and longitudinal designs, the Joanna Briggs Institute (JBI) Critical Appraisal Checklists will be used. These checklists assess methodological rigor in terms of sample selection, measurement validity and reliability, confounding factors, statistical analysis, and clarity of outcome reporting.

For qualitative studies, the Critical Appraisal Skills Programme (CASP) Qualitative Checklist will be employed to evaluate credibility, transferability, dependability, and confirmability. The appraisal will focus on research design, data collection methods, reflexivity, ethical considerations, and coherence between data and interpretations.

For mixed-methods studies, the Mixed Methods Appraisal Tool (MMAT) will be used to integrate the quality assessment of both qualitative and quantitative components.

Two independent reviewers will conduct the quality assessment process. Any disagreements will be resolved through discussion or consultation with a third reviewer. The quality ratings will not be used as exclusion criteria but will inform the interpretation of findings and sensitivity analysis where applicable. A summary of risk of bias will be presented in both tabular and narrative formats.

Strategy of data synthesis Data synthesis will be conducted using a narrative synthesis approach, given the expected heterogeneity in study designs, outcome measures, and intervention characteristics. The synthesis will follow established guidelines for systematic narrative reviews.

First, a descriptive analysis will be performed to summarize the general characteristics of the included studies, including publication year, country or region, participant characteristics, educational level, research design, type of Generative AI tool, and outcome indicators related to self-regulated learning. These characteristics will be organized and presented in structured tables and visual summaries.

Second, a thematic synthesis will be carried out to integrate findings across studies. The analysis will focus on key dimensions of self-regulated learning,

including cognitive strategies, metacognitive regulation, motivational processes, and behavioral engagement. Each study's findings will be coded and grouped according to these conceptual dimensions to identify common patterns, similarities, and differences in how Generative AI supports or challenges students' self-regulated learning.

Third, the synthesis will explore contextual and methodological factors, such as educational level (secondary vs. higher education), learning context (online, blended, face-to-face), type of Generative AI application (e.g., chatbots, writing assistants), and study design. These factors will be used to interpret variations across research findings and to identify gaps and underexplored areas in the current literature.

For qualitative and mixed-methods studies, thematic content analysis will be conducted to extract key themes, mechanisms, and explanatory insights related to students' experiences and perceptions of using Generative AI for self-regulated learning. Findings will be synthesized narratively to provide an integrated understanding of both positive and negative impacts.

Subgroup analysis Although no statistical meta-analysis will be conducted, subgroup analyses will be performed at a conceptual and narrative level to explore potential variations in findings across different study characteristics and educational contexts.

Specifically, the synthesis will compare and interpret results across the following subgroups:

Educational level: Differences between secondary school students and higher education students will be examined to identify whether the role of Generative Artificial Intelligence (GenAI) in supporting self-regulated learning varies by developmental stage and learning demands.

Type of Generative AI tools: Studies will be grouped according to the type of GenAI application used (e.g., AI chatbots, large language models, AI writing assistants, intelligent tutoring systems) to examine how different forms of AI support influence self-regulated learning processes.

Learning context: Subgroups will be formed based on learning environments, including online, blended, and face-to-face settings, to explore contextual influences on the effectiveness of GenAI-supported self-regulated learning.

Study design and methodological approach: Differences between quantitative, qualitative, and mixed-methods studies will be analyzed to identify how methodological approaches shape reported outcomes and interpretations.

Focus dimension of self-regulated learning: Findings will also be organized according to different SRL dimensions, including cognitive strategies, metacognitive regulation, motivation, and behavioral engagement.

These subgroup analyses will be presented through structured comparisons, narrative synthesis, and tabulated summaries, with the aim of identifying patterns, contextual dependencies, and gaps in current research, rather than providing statistical effect comparisons.

Sensitivity analysis Although no meta-analysis will be conducted in this review, a qualitative sensitivity analysis will be performed to assess the robustness and stability of the synthesized findings.

First, the review findings will be re-examined after excluding studies with low methodological quality or high risk of bias, as identified during the quality appraisal process. Differences in the themes, patterns, and overall conclusions before and after exclusion will be compared to determine whether the main conclusions are overly dependent on lower-quality evidence.

Second, sensitivity analysis will be conducted by comparing findings across studies with different research designs (e.g., experimental vs. non-experimental, qualitative vs. quantitative). This will help assess whether the conclusions are consistent across methodological approaches or are driven primarily by one type of study.

Third, sensitivity will also be explored based on types of Generative Artificial Intelligence tools, such as AI chatbots, large language models, and AI writing assistants, to examine whether the synthesized conclusions remain stable when focusing on specific categories of GenAI applications.

In addition, the influence of publication year and research context (e.g., online vs. face-to-face learning environments, secondary vs. higher education settings) will be considered to explore whether findings are sensitive to time periods or specific implementation contexts.

Through these procedures, the review will evaluate the consistency and reliability of its conclusions and ensure that key interpretations are not disproportionately affected by methodological limitations or outlier studies.

Country(ies) involved China.

Keywords Generative AI; Self-regulated learning; Artificial intelligence in education; Educational technology; Learning strategies; Systematic review.

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