GENERATIVE AI INSTRUCTIONAL DESIGN FOR LMS-BASED DISTANCE HIGHER EDUCATION: A UNESCO–OECD INFORMED SYSTEMATIC REVIEW

ANA LUÍSA MATEUS OLIVEIRA CHANÇA TORRES

Santarém Polytechnic University, Digital Literacy and Social Inclusion CIAC-PLDIS-SPU, Portugal
E-mail: ana.torres@ese.ipsantarem.pt

Abstract - The rapid expansion of LMS-based distance higher education has exposed reported limitations in instructional design quality and learner support, particularly in fostering self-regulated learning (SRL) [1], [8]. At the same time, Generative Artificial Intelligence (GenAI) introduces new opportunities for adaptive feedback, metacognitive scaffolding, and instructional design automation [15], [16]. However, research remains fragmented, with instructional design, SRL, and GenAI largely examined in isolation. This study conducts a systematic scoping review informed by PRISMA 2020 guidelines [22], analyzing 25 studies retrieved from Scopus and Web of Science (2021–2026). The synthesis reveals three dominant yet weakly integrated research streams: LMS-based instructional design, technology-enhanced SRL, and emerging GenAI applications. In response, this study introduces a three-layer conceptual framework integrating instructional design, SRL processes, and GenAI mediation, aligned with human-centered AI principles [20], [21]. The study contributes by advancing theoretical integration and offering design implications for AI-enhanced LMS environments.

Keywords - Generative artificial intelligence; instructional design; self-regulated learning; LMS; Higher Education; Systematic Literature Review; UNESCO; OECD.

I. INTRODUCTION

The digital transformation of higher education has accelerated globally, with distance and hybrid learning becoming structural components of educational provision [1]. Learning Management Systems (LMS), such as Moodle, are central to this transformation, supporting content delivery, communication, and assessment. However, their widespread adoption has not ensured pedagogical quality, with many courses remaining content-centric and weakly aligned with learning objectives [1].

Self-regulated learning (SRL) is a key determinant of success in online environments, encompassing learners' ability to plan, monitor, and evaluate their learning processes [4]–[6]. Empirical evidence confirms its strong relationship with academic performance and engagement [7], [8]. Despite this, SRL is often insufficiently embedded in instructional design, particularly in LMS-based courses.

Simultaneously, Generative Artificial Intelligence (GenAI), including large language models such as ChatGPT, is transforming educational practices through adaptive feedback, content generation, and real-time support [15], [16]. While these tools offer significant potential, they also raise distinct concerns: at the pedagogical level, risks of cognitive overreliance and reduced metacognitive effort have been documented; at the institutional and ethical level, challenges related to academic integrity and transparency must be separately considered [14], [15].

Despite growing interest in these domains, research remains fragmented. Instructional design, SRL, and GenAI are typically studied independently, limiting the development of coherent models for AI-enhanced learning environments. This study addresses this gap by examining the intersection of these domains through a systematic review.

The study is guided by three research questions:
RQ1: How is instructional design conceptualized in LMS-based higher education?
RQ2: What role do technologies play in supporting SRL?
RQ3: How is GenAI integrated into instructional design and SRL frameworks?

In this context, the present study has a dual aim. First, it conducts a systematic scoping review of research published between 2021 and 2026 that addresses instructional design, self-regulated learning (SRL), and generative AI in LMS-based higher education. Second, based on the thematic synthesis of 25 studies, it advances a three-layer conceptual framework that integrates LMS-based instructional design (Layer 1), SRL processes (Layer 2), and GenAI mediation (Layer 3) within a human-centered AI perspective. Rather than empirically testing this model, the study positions the framework as a theoretically grounded proposal derived from the literature, intended to guide future design-based and experimental research on GenAI-enhanced distance higher education.

II. METHODOLOGY

A. Review design and protocol

This systematic scoping review was conducted following PRISMA 2020 guidelines with a pre-registered protocol. A scoping review design was adopted over a full systematic review [23] as it maps evidence and identifies gaps without requiring formal quality appraisal; effect sizes in Section III.C should

therefore be interpreted with caution. The PICo framework structured the review across Population (higher education students/instructors), Interest (instructional design, SRL, GenAI), and Context (online/blended/LMS-based higher education). As a single-author review, inter-rater reliability was not formally established; an independent check of 20% of screening decisions (n = 278) identified no systematic discrepancies, though independent replication is recommended.

Inclusion targeted: (i) 2021–2026 publications (post-pandemic online learning + GenAI emergence); (ii) peer-reviewed empirical studies/systematic reviews; (iii) explicit engagement with ≥1 core construct, prioritizing intersections.

B. Search strategy

Searches were conducted in the Scopus and Web of Science databases, selected due to their comprehensive coverage of high-impact research in education and educational technology. The search strategy combined controlled descriptors and free-text terms related to generative artificial intelligence, self-regulated learning, instructional design, and online or distance education, following established best practices for systematic reviews [1], [24].

In compliance with PRISMA 2020 Item 7, the full Boolean search string applied in Scopus was as follows (an equivalent string was adapted for Web of Science field codes):
("generative artificial intelligence" OR "large language model" OR "ChatGPT") AND
("self-regulated learning" OR SRL) AND
("online learning" OR "distance education" OR "learning management system").

To mitigate publication bias and capture relevant studies that may not explicitly reference GenAI, additional search strings were employed focusing on instructional design and SRL in LMS contexts. This strategy ensured broader coverage of foundational research necessary for conceptual integration.
The combined searches yielded 1624 records. These included studies addressing self-regulated learning (n = 423), online and distance learning (n = 684), and generative AI or large language models (n = 210), reflecting the relative maturity and distribution of the research domains.

C. Screening and eligibility

All retrieved records were exported to a reference management system, where duplicates (n = 233) were identified and removed, resulting in 1391 unique records.

The screening process followed a two-stage procedure in accordance with PRISMA 2020 guidelines [22]. In the first stage (title and abstract screening), studies were excluded if they: (i) did not focus on higher education; (ii) were purely technical or computational studies without educational application; (iii) addressed exclusively K–12 or corporate training contexts; or (iv) consisted of editorials or non-empirical opinion pieces. This stage resulted in the exclusion of 1346 records, leaving 45 studies for full-text assessment.

In the second stage (full-text eligibility), studies were included if they met the following criteria: (i) empirical research or systematic review design; (ii) higher education context; (iii) online, blended, or LMS-based learning environment; and (iv) explicit engagement with at least one of the three core domains (instructional design, SRL, or GenAI). Twenty studies were excluded at this stage, resulting in a final corpus of 25 articles.

The selection process is summarized in Fig. 1, ensuring transparency and reproducibility of the review procedure.

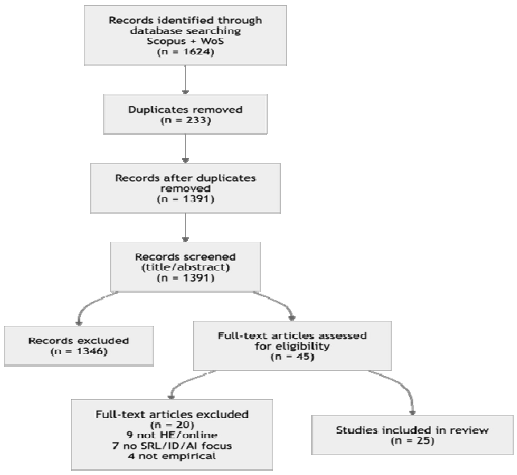


Fig. 1 shows the PRISMA 2020 flow diagram summarizing identification, screening, eligibility and inclusion phases, making the selection process transparent and reproducible [22].

D. Data extraction and study characteristics

A structured data extraction matrix was developed and iteratively refined to ensure consistency and analytical depth. For each study, the following information was recorded: publication year, geographical context, educational setting, theoretical framework, type of technological intervention, and key outcomes (e.g., SRL measures, academic performance, learner perceptions).
This systematic extraction enabled cross-study comparison and supported the identification of patterns across the three core domains. The process followed established methodological guidance for systematic reviews in educational research [22], [24].

E. Synthesis approach

A thematic synthesis approach was employed, combining deductive and inductive coding strategies. Deductive coding was guided by the three predefined domains: instructional design, self-regulated learning, and generative AI. Inductive coding allowed additional themes to emerge from the data, including teacher–AI collaboration, analytics-informed redesign,

and ethical considerations.

To enhance methodological rigor, the coding process involved iterative validation, and categorization decisions were refined through analytical comparison across studies. Studies were subsequently grouped into clusters based on their primary focus and technological configuration (e.g., LMS-based design, SRL interventions, GenAI applications).

This integrative synthesis enabled the identification of relationships and gaps across the domains, directly informing the development of the conceptual framework presented in Section IV.

III. RESULTS

A. Temporal and geographical trends

The 25 studies included in the final corpus span the period between 2021 and 2026, reflecting the rapid evolution of both online higher education and generative AI technologies. A clear temporal concentration is observed after 2023, coinciding with the widespread public release and adoption of large language models such as ChatGPT [15], [16]. This trend suggests that the integration of generative AI into educational research is still emerging and remains in an early stage of conceptual and empirical development.

Geographically, the distribution of studies reveals a strong concentration in Asian contexts, particularly China (36%), Indonesia (20%), and Taiwan (16%). Contributions from Europe and North America are comparatively limited, and notably, no empirical studies were identified that explicitly address the integration of instructional design, self-regulated learning (SRL), and GenAI within Portuguese higher education. This imbalance highlights a significant geographical research gap and suggests the need for context-sensitive investigations in underrepresented regions.

B. Instructional design in LMS-based distance education

Eight studies (32%) focused primarily on instructional design within LMS-based environments, including platforms such as Moodle and institutional virtual learning systems. These studies emphasize the importance of aligning learning outcomes, activities, and assessment in accordance with principles of constructive alignment and cognitive load management [1].

Across the analyzed studies, three recurring design patterns were identified: (i) structured sequencing of learning activities with increasing complexity; (ii) integration of formative assessment mechanisms; and (iii) use of learning analytics to support iterative course redesign [1], [10]. These approaches reflect a shift towards more data-informed instructional design practices.

The analysis also reveals persistent limitations. Many LMS-based courses remain content-centric, prioritizing information delivery over active engagement and learner involvement. Explicit support for SRL processes is often absent or only implicitly embedded within course design. This indicates a misalignment between established pedagogical principles and actual instructional practices in online higher education.

Recent studies propose more flexible and adaptive design frameworks, as well as faculty development initiatives aimed at enhancing pedagogical use of LMS platforms. These approaches rarely incorporate emerging GenAI capabilities, suggesting that instructional design research has not yet fully integrated recent technological developments.

C. Technology-enhanced self-regulated learning

Twelve studies (48%) examined interventions designed to support SRL through technological means, including learning analytics dashboards, metacognitive prompts, pedagogical agents, and intelligent recommender systems. These studies provide robust empirical evidence of the effectiveness of technology-mediated SRL support. Several studies report statistically significant improvements in learning outcomes. For example, AI-based pedagogical agents incorporating metacognitive scaffolding demonstrated moderate-to-large effects on SRL ($d = 0.68$) and co-regulation ($d = 0.52$) [11]. Similarly, gamified learning analytics dashboards were associated with improved monitoring behaviors and academic performance ($\eta^2 = 0.14$) [12]. Additional findings indicate that technological proficiency mediates the relationship between SRL and academic achievement ($\beta = 0.41$) [14]. Meta-analytical evidence further supports these findings, with moderate pooled effects ($g = 0.45$) reported for SRL interventions in online higher education [8], [9]. Collectively, these results confirm that SRL can be effectively supported through technology when interventions are pedagogically structured and aligned with learning processes.

The analysis also reveals a conceptual limitation: most studies conceptualize technology in terms of learning analytics, intelligent tutoring systems, or rule-based agents, with limited attention to generative AI. As a result, the transferability of these findings to GenAI contexts remains uncertain, highlighting an important gap in current research.

D. Emerging uses of generative AI

Five studies (20%) explicitly address the use of generative AI or large language models in higher education contexts. These studies primarily explore three areas of application: (i) AI-assisted academic writing and automated feedback generation; (ii) support for instructional design processes, including content prototyping; and (iii) student use of GenAI for conceptual clarification and task completion [15], [16], [18].

Findings consistently indicate that GenAI tools are perceived as useful for accelerating feedback, improving text structuring, and supporting understanding of complex concepts. However, these benefits are accompanied by significant concerns, including risks of cognitive dependency, reduced critical thinking, and challenges related to academic integrity and transparency [15], [16].

Existing GenAI research is predominantly exploratory and tool-oriented, focusing on user perceptions and ethical implications rather than systematic pedagogical integration. No studies embed GenAI within SRL-oriented instructional design in LMS contexts, representing a critical conceptual and empirical gap.

E. Research stream integration

The synthesis of findings reveals three dominant but weakly integrated research streams: (i) instructional design in LMS environments; (ii) technology-enhanced SRL; and (iii) emerging applications of generative AI.

Instructional design research primarily focuses on course structure and alignment but rarely incorporates AI-driven support mechanisms [1]. SRL research provides strong evidence for the effectiveness of technology-mediated interventions but is largely limited to analytics-based or rule-based systems rather than generative AI [10], [14]. In contrast, GenAI research is predominantly exploratory, emphasizing tool usage, user perceptions, and ethical considerations, with limited connection to established pedagogical frameworks [15], [16].

Table 3 exemplifies this direct link between the 25 reviewed studies and the proposed framework, showing how each research stream informs a specific layer:

Ref.	Author(s) / Year	Primary Focus	Key Findings	Framework Layer(s)
[1]	Bond *et al.* (2021)	LMS-based instructional design	Constructive alignment and learning analytics improve course quality	Layer 1 – Instructional Design
[10]	*Gašević et al.* (2021)	Learning analytics for course redesign	Learning analytics support iterative course redesign and pedagogical refinement	Layer 1 – Instructional Design
[11]	*Martha et al.* (2023)	Metacognitive pedagogical agents	Significant effects on SRL ($d = 0.68$) and co-regulation ($d = 0.52$)	Layer 2 – SRL Processes
[12]	Hu *et al.* (2024)	Gamified learning analytics dashboards	Improved monitoring behaviours and learning performance ($\eta^2 = 0.14$)	Layer 2 – SRL Processes
[14]	Jin *et al.* (2023)	Technological proficiency in SRL	Technological proficiency mediates SRL and academic achievement ($\beta = 0.41$)	Layer 2 – SRL Processes
[15]	Tilli *et al.* (2023)	ChatGPT in education	Identifies opportunities and *ethical challenges of GenAI*	Layer 3 – GenAI Mediation
[16]	*Kasneci et al.* (2023)	Large language models (LLMs)	*Adaptive feedback potential with risks of cognitive dependency*	Layer 3 – GenAI Mediation

Table 3. Representative synthesis of the reviewed studies and link to the three-layer framework (selection of 7 out of 25)
Note: N=25 studies; distribution: 32% Layer 1, 48% Layer 2, 20% Layer 3.

This fragmentation constrains the development of coherent, theory-driven models for AI-enhanced learning environments.

Taken together, the findings indicate the need for a unified conceptual approach that aligns instructional design, SRL processes, and GenAI mediation within LMS-based environments. This need directly informs the development of the conceptual framework presented in the following section.

IV. PROPOSED CONCEPTUAL FRAMEWORK

Drawing on the synthesis of findings, this study advances a theoretically grounded conceptual framework for generative AI-enhanced LMS-based distance higher education. The framework addresses the fragmentation identified across instructional design, self-regulated learning (SRL), and generative AI by integrating these domains into a unified, pedagogically coherent model.

Rather than conceptualizing GenAI as an external or supplementary tool, the framework positions it as a structured mediational layer embedded within the instructional design architecture and aligned with SRL processes. This approach reflects a shift from tool-centric to pedagogy-driven integration, ensuring that technological affordances are subordinated to learning objectives and regulatory processes.

The framework is organized into three interdependent layers: (i) LMS-based instructional design (foundation), (ii) self-regulated learning processes (core mediation), and (iii) generative AI mediation (adaptive support), as illustrated in Fig. 2.

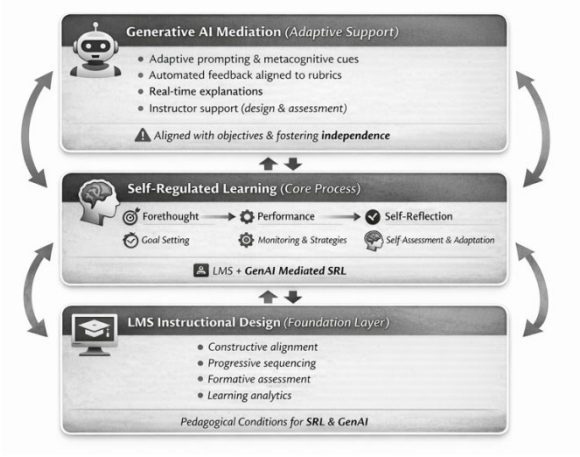


Figure 2. Three-layer conceptual framework for GenAI-enhanced LMS-based distance higher education.

A. Layer 1: LMS-based instructional design (foundation)

The foundational layer defines the pedagogical architecture of the learning environment, including learning outcomes, content structure, learning activities, and assessment strategies. It is grounded in principles of constructive alignment and cognitive load management, ensuring coherence between objectives, tasks, and evaluation [1].

This layer performs a structuring function, organizing the learning experience into sequenced modules with progressively increasing complexity. It incorporates formative assessment mechanisms and learning analytics to support iterative course redesign and evidence-based pedagogical decisions [1], [10].

Importantly, this layer establishes the conditions under which both SRL processes and GenAI mediation can operate effectively. Without a coherent instructional design, technological interventions risk becoming fragmented and pedagogically misaligned. Therefore, instructional design functions as the primary organizing structure of the model.

B. Layer 2: Self-regulated learning processes (core mediation)

The second layer represents the core learning processes, conceptualized through the lens of self-regulated learning. Drawing on Zimmerman's cyclical model, SRL is operationalized across three phases: forethought (goal setting and planning), performance (strategy use and monitoring), and self-reflection (evaluation and adaptation) [4],[6].

Within LMS environments, instructional design acts as an external regulator that shapes and scaffolds these processes. This includes the integration of metacognitive prompts, structured learning pathways, monitoring tools such as dashboards and analytics, and opportunities for reflection through self-assessment activities.

Empirical evidence demonstrates that such structured support enhances learner engagement and academic performance [8], [9], [11]. However, as identified in the results, SRL support is often inconsistently implemented and rarely explicitly connected to emerging AI technologies.

In this framework, SRL is positioned as the central mediating process linking instructional design and technological support. It defines how learners interact with the learning environment and how support mechanisms, human or artificial, should be structured.

C. Layer 3: Generative AI Mediation (Adaptive Support)

The third layer introduces generative AI as an adaptive mediational component embedded within the instructional design and SRL processes. Unlike traditional AI applications, which often rely on predefined rules or analytics, GenAI enables context-sensitive, real-time support tailored to learner needs.

In this model, GenAI performs four primary functions:
(i) adaptive prompting to support planning and metacognition.
(ii) real-time explanation and conceptual clarification.
(iii) generation of formative feedback aligned with assessment criteria; and
(iv) support for instructional design workflows, including content prototyping and assessment design [15], [16], [18], [19].

Crucially, GenAI is not conceptualized as an autonomous agent but as a pedagogically constrained mediator. Its functions are explicitly defined by instructional goals and aligned with SRL phases. This ensures that AI supports, rather than replaces, cognitive and metacognitive processes.

The framework also incorporates ethical considerations, including transparency, accountability, and the mitigation of risks such as cognitive dependency and academic misconduct, in line with UNESCO and OECD human-centered AI principles [20], [21].

D. Framework dynamics

The framework conceptualizes dynamic interactions across the three layers. Instructional design provides the structural foundation, SRL represents the core learning processes, and GenAI acts as an adaptive layer that enhances and mediates these processes.

The effectiveness of GenAI is contingent upon its alignment with both instructional design and SRL. Misaligned use of AI—such as providing answers without supporting reflection—may undermine learning processes. Conversely, when aligned with pedagogical intent, GenAI can enhance metacognition, support feedback loops, and promote deeper engagement.

This dynamic perspective emphasizes that the educational value of GenAI does not reside in the

technology itself, but in how it is integrated within a coherent pedagogical system. Three testable propositions are derived: (P1) constructive-alignment design predicts higher SRL engagement than content-centric courses; (P2) SRL-phase-structured GenAI interactions predict greater metacognitive awareness than unstructured use; (P3) pedagogy-first GenAI training predicts greater instructor confidence in teacher agency and transparency.

E. Alignment with international standards

The framework operationalizes key principles advocated by UNESCO and OECD for the ethical and pedagogically grounded use of AI in education [20], [21]:

Pedagogy-first integration: AI is subordinated to instructional design and learning objectives.

Transparency: the role and limitations of AI are explicitly communicated to learners.

Equity and inclusion: access to AI-supported learning is designed to accommodate diverse learner profiles.

Teacher agency: instructors retain control over AI integration and pedagogical decision-making.

By embedding these principles within the model, the framework ensures that technological innovation is aligned with broader educational values and responsibilities.

F. Theoretical and Practical Implications

The framework contributes theoretically by unifying three fragmented domains and explicitly positioning GenAI within the pedagogical architecture of LMS environments.

From a practical perspective, the framework provides guidance for educators and instructional designers in structuring AI-supported learning environments. It supports the design of LMS courses where GenAI is embedded within learning activities, feedback mechanisms, and reflective processes, rather than being used as an external tool.

The framework establishes a foundation for future empirical research, particularly design-based and experimental studies examining the impact of GenAI-supported SRL on learning outcomes in authentic educational contexts.

IV. DISCUSSION AND CONCLUSIONS

This study examined the intersection of instructional design, self-regulated learning (SRL), and generative artificial intelligence (GenAI) in LMS-based higher education, revealing a fragmented research landscape across these domains. While each field has developed robust theoretical and empirical foundations independently, their integration remains limited, constraining the development of coherent and pedagogically grounded approaches to AI-enhanced learning environments. Regarding RQ1, instructional design is predominantly framed through constructive alignment and cognitive load principles, with SRL scaffolding and GenAI integration largely absent. Regarding RQ2, technology-mediated SRL interventions produce moderate positive effects, though predominantly through rule-based rather than generative systems. Regarding RQ3, explicit GenAI integration into instructional design and SRL frameworks is absent from the empirical literature, confirming the primary gap the proposed framework addresses.

Beyond mapping this fragmented landscape, the study deliberately assumes a dual contribution as a review and framework paper. On the one hand, the scoping review synthesizes dispersed evidence on LMS-based instructional design, technology-mediated SRL, and emerging GenAI applications, highlighting convergences and blind spots across these domains. On the other hand, the proposed three-layer framework is explicitly derived from this synthesis: Layer 1 is informed by recurrent patterns in LMS course structure and constructive alignment, Layer 2 by robust findings on SRL-supportive technologies, and Layer 3 by exploratory yet converging insights on GenAI's potential and risks. In this sense, the framework does not claim empirical validation, but rather offers a theoretically grounded, literature-informed model to be tested and refined in future empirical studies.The findings highlight a fundamental misalignment between technological innovation and pedagogical theory. Instructional design research emphasizes structural alignment and course organization [1], whereas SRL research focuses on learners' regulatory processes [4],[6]. In contrast, GenAI research remains largely tool-centric, prioritizing efficiency and user perceptions over pedagogical integration [15], [16]. This divergence limits the development of theory-driven models capable of guiding meaningful AI adoption in education.

Consistent with prior research, SRL emerges as a central mechanism in online learning, with technology-enhanced interventions demonstrating moderate positive effects on performance and engagement [8], [9], [11]. However, these interventions are primarily based on analytics or rule-based systems, with limited integration of generative AI. At the same time, GenAI studies remain exploratory and insufficiently anchored in instructional design and SRL theory, often positioning AI as an external support tool rather than an embedded pedagogical component.

In response, this study advances a conceptual framework that integrates instructional design, SRL, and GenAI within LMS environments. The framework positions instructional design as the structural foundation, SRL as the core learning process, and GenAI as a structured mediational layer aligned with pedagogical goals. This approach shifts the focus from tool-driven innovation to pedagogy-first integration, ensuring that AI supports metacognitive processes

rather than replacing them.

The study contributes in three main ways. First, it advances theoretical integration across previously fragmented domains, bridging instructional design, SRL, and GenAI within a unified model. Second, it provides a structured synthesis of emerging research, identifying key gaps and limitations. Third, it offers practical implications for the design of AI-enhanced LMS environments, emphasizing the need to align GenAI functionalities with SRL processes and instructional goals.

From a practical perspective, effective integration of GenAI requires a shift in instructional design practices. Educators should embed AI within learning activities that promote reflection, feedback, and active engagement, rather than using it solely as a productivity tool. This includes designing prompts that foster metacognition, aligning AI-generated feedback with assessment criteria, and ensuring transparency in AI use. Two concrete examples: (i) a three-stage metacognitive prompt protocol aligned with Zimmerman's SRL phases — planning prompt before a task, AI feedback for mid-task monitoring, and AI-generated criteria for self-reflection; (ii) a transparency-by-design feedback protocol where learners annotate which rubric criterion each AI suggestion addresses before incorporation, reinforcing critical evaluation.

The study also reinforces the importance of a human-centered approach to AI in education, as advocated by UNESCO and OECD [20], [21]. Ensuring transparency, equity, and teacher agency is essential to prevent risks such as cognitive dependency and ethical misuse.

Despite its contributions, the study has limitations, including the restriction to two databases and the relatively small number of studies explicitly addressing GenAI. These limitations reflect the emerging nature of the field and suggest caution in generalizing findings. A further limitation is the pronounced geographical skew of included studies (China 36%, Indonesia 20%, Taiwan 16%), reflecting high LMS adoption and permissive GenAI regulation in those contexts. Caution is warranted when applying findings to European or Portuguese settings, where the EU AI Act, GDPR, and distinct pedagogical traditions may substantially alter implementation dynamics.

Future research should focus on empirically validating the proposed framework through design-based and experimental studies in authentic educational contexts. Further work is needed to examine how GenAI influences different dimensions of SRL, including metacognition, motivation, and self-reflection, as well as to expand research across diverse contexts.

In conclusion, this study contributes to repositioning generative AI from a technological innovation to a pedagogically embedded component of instructional design. Prior work has predominantly positioned GenAI as a productivity and efficiency tool [15], [16], [18], with limited connection to instructional theory or SRL frameworks [19]. The present study challenges this tool-centric paradigm by embedding GenAI within a structured pedagogical architecture. By integrating instructional design, SRL, and GenAI within a unified framework, it provides a foundation for more coherent, effective, and ethically grounded approaches to AI-enhanced higher education.

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