



Journal of Advanced Research in Computing and Applications

Journal homepage:
<https://karyailham.com.my/index.php/arca>
2462-1927



Integrating Artificial Intelligence in Design-Based Learning: A Systematic Literature Review Guided by Self-Determination Theory

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ARTICLE INFO

ABSTRACT

Article history:

Received 3 March 2026

Received in revised form 19 May 2026

Accepted 25 May 2026

Available online 16 June 2026

Keywords:

Generative artificial intelligence; GenAI; design-based learning; Self-Determination Theory; built environment education; pedagogical framework

Artificial Intelligence (AI), particularly generative AI, is increasingly transforming built environment education. In design studio contexts, Design-Based Learning (DBL) emphasizes iterative design, reflective practice, creativity, and learner autonomy. However, existing research on AI integration in built environment education remains fragmented and lacks strong theoretical grounding, particularly regarding student motivation and engagement. This study addresses this gap by examining AI integration in DBL through the lens of Self-Determination Theory (SDT). A Systematic Literature Review (SLR) guided by the PRISMA 2020 framework was conducted using peer-reviewed studies from major academic databases. Relevant articles focusing on AI, DBL, and built environment education were selected using predefined inclusion and exclusion criteria and analyzed thematically. The review found that AI is widely used to support rapid prototyping, design visualization, iterative feedback, and creative exploration within DBL environments. Findings suggest that AI has the potential to enhance learner autonomy, competence, and engagement through personalized and flexible learning experiences. However, most existing studies remain descriptive and technology-focused, with limited theoretical discussion connecting AI use to psychological and motivational constructs. The study concludes that although AI offers significant potential to enhance design-based learning, its pedagogical integration remains under-theorized. By applying SDT as a conceptual framework, this review provides guidance for future research and supports educators in developing more pedagogically grounded and ethically informed AI integration strategies.

1. Introduction

1.1 The Artificial Intelligence in Education

The rapid evolution of AI in education extends beyond technological integration, fundamentally reshaping pedagogical approaches and requiring a re-evaluation of existing educational paradigms, particularly within design-based learning environments [1]. In higher education, AI-driven tools such as chatbots and adaptive learning systems enhance student engagement and support more

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<https://doi.org/10.37934/arca.43.1.148160>

personalized learning experiences, necessitating context-sensitive frameworks for effective implementation [1].

This shift reflects a transition toward a human-AI symbiosis, where AI assumes co-agency roles in instructional design by dynamically adapting, delivering, and assessing content while collaborating with educators in shaping learning experiences [1,2]. Unlike earlier “learning from” models, where technology functioned primarily as a content delivery mechanism, contemporary approaches emphasize “learning with” AI as a co-creator in knowledge construction [3].

AI’s perceived autonomy and usability play a crucial role in fostering self-directed learning motivation. Its ability to support autonomy, ease of use, and perceived usefulness contributes to enhanced self-efficacy and learning engagement, particularly within design-based contexts [4]. Empirical evidence further suggests that AI-supported instruction can improve learning outcomes compared to traditional approaches [5]. However, the effectiveness of AI depends on specific tools

such as intelligent tutoring systems and predictive analytics are integrated into pedagogical practices [1].

From a psychological perspective, AI integration must be examined through frameworks such as Self-Determination Theory (SDT), which emphasizes the satisfaction of autonomy, competence, and relatedness as key drivers of intrinsic motivation [6,7]. AI-enabled personalized feedback and adaptive learning environments have the potential to address these needs, but their effectiveness is highly dependent on pedagogical alignment and contextual implementation. Additionally, standardized AI applications may fail to accommodate diverse learner needs, particularly in culturally varied contexts where flexibility and meaningful feedback are essential [4].

At a broader level, the expansion of AI in education introduces both opportunities and risks. While AI enables unprecedented personalization and cognitive support [8], it also raises concerns about “learnification,” where education is reduced to a purely technical process, neglecting its ethical, social, and human dimensions [9]. Therefore, a critical and systematic synthesis of existing research is necessary to understand the complex interplay between AI, pedagogy, and learner motivation, and to establish a robust theoretical foundation for its effective integration [4].

1.2 Design-Based Learning in the Digital Age

Design-Based Learning (DBL) has emerged as a key pedagogical approach for developing 21st-century skills within AI-enhanced educational environments. It is characterized by iterative processes including problem definition, information gathering, prototyping, and evaluation [10]. These processes require students to engage in design thinking, incorporating creativity, empathy, and critical reflection [11].

Within Science, Technology, Engineering, and Mathematics (STEM) and design disciplines, DBL plays a significant role in fostering computational thinking and technical literacy [10]. The integration of AI into DBL environments further enhances these processes by supporting ideation, prototyping, and reflection. Generative AI tools, such as large language models and image generators, help bridge technical skill gaps, enabling students to focus on higher-level conceptual development [12].

Empirical studies indicate that AI-supported DBL improves creative self-efficacy and reflective thinking compared to traditional approaches [11]. By accelerating prototyping and offering diverse perspectives, AI acts as a catalyst for innovation. However, concerns remain regarding over-reliance on AI, which may reduce cognitive effort and hinder the development of foundational creative skills [13].

Therefore, effective integration requires a balanced approach in which AI augments, rather than replaces, human cognition. Maintaining learner agency within iterative design processes is essential to preserving the core principles of DBL [13].

1.3 Theoretical Framework: Self-Determination Theory

To understand the psychological mechanisms underlying AI-driven learning, this study adopts Self-Determination Theory (SDT), developed by Ryan and Deci, as its theoretical foundation [14]. SDT posits that autonomous motivation is driven by the satisfaction of three fundamental psychological needs: autonomy, competence, and relatedness.

Autonomy refers to the ability of learners to take control of their own learning processes. In AI-driven environments, autonomy is supported through personalized learning pathways, flexible pacing, and opportunities for learner-driven exploration [8,15,16]. This allows students to engage more meaningfully with content based on their individual preferences and learning styles.

Competence involves the ability to effectively master challenges and develop skills. AI technologies enhance competence by providing adaptive feedback, scaffolding learning tasks, and offering metacognitive support aligned with learners' developmental levels [9,15,16]. These features enable learners to build confidence as they progressively achieve learning goals.

Relatedness refers to the sense of connection and belonging with others. Although AI-mediated interaction may not fully replicate human relationships, it can simulate social engagement through interactive systems and responsive feedback. Such perceived interaction can still contribute positively to learner motivation, even if the depth of human connection remains limited [15-17].

Figure 1 illustrates the three core components of Self-Determination Theory: autonomy, competence, and relatedness, and their roles in supporting intrinsic motivation within learning environments.

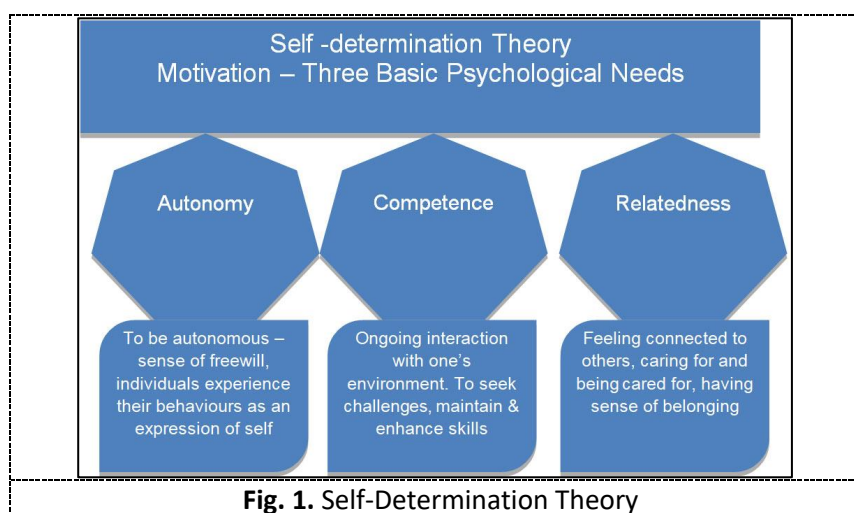


Fig. 1. Self-Determination Theory

1.4 Literature Review: AI, Motivation, and Engagement

A growing body of research highlights the potential of artificial intelligence (AI) to enhance motivation and engagement in Design-Based Learning (DBL) environments by supporting the three psychological needs identified in Self-Determination Theory (SDT), namely autonomy, competence, and relatedness [4,14,15]. AI-enabled features such as personalization, adaptive feedback, and flexible learning pathways contribute to increased learner agency and self-regulation [1,18].

However, these benefits are accompanied by notable challenges. Overreliance on generative AI may reduce cognitive effort, promote superficial learning, and weaken problem-solving abilities [13,19]. Poorly integrated AI tools risk displacing critical reflection and diminishing learner agency.

The effectiveness of AI is therefore highly dependent on pedagogical design. Evidence indicates that its impact on engagement is moderated by instructional quality, learner autonomy, and the level of pedagogical mediation [18,20]. When embedded within structured approaches such as project-based learning and flipped classrooms, AI can significantly enhance engagement, metacognitive development, and reflective practice [18,19].

In DBL contexts, AI has been shown to improve creative self-efficacy, reflective thinking, and design performance, particularly among lower-performing learners [11,12,21]. Additionally, AI can reduce learning anxiety, support collaboration, and facilitate self-directed exploration [14,22].

Table 1 summarises the key findings from the literature, synthesising the roles of AI in influencing motivation and engagement within DBL environments through the lens of Self-Determination Theory. The table highlights both the positive contributions of AI such as enhancing autonomy and competence, and the potential risks associated with overreliance, which may undermine intrinsic motivation. It also demonstrates that the impact of AI is not uniform but is moderated by pedagogical design and implementation strategies.

Table 1
 Synthesis of AI, motivation, and engagement in DBL

Author(s)	Context / AI Application	Key Contribution	Impact on Motivation	SDT Dimension
Zhai & Nezakatgoo (2025); Alqurni (2026); IJLLTS (2024)	AI in learning environments	AI supports personalized learning and autonomy	Enhances motivation through psychological needs satisfaction	Autonomy, Competence, Relatedness
Long et al. (2026); Li et al. (2026)	Adaptive systems, AI-supported learning	Enables self-regulated learning and flexible pathways	Improves engagement and learner agency	Autonomy, Competence
Tsakalerou et al. (2026); Song et al. (2026)	Generative AI overuse	Overreliance reduces cognitive effort	Undermines intrinsic motivation and deep learning	Autonomy, Competence
Fu et al. (2026); Xia et al. (2025); Long et al. (2026)	Meta-analysis of GenAI	Effect depends on pedagogy and learner agency	Mixed impact on engagement	All (moderated)

Despite these advancements, the literature remains largely descriptive and lacks strong theoretical grounding, particularly regarding long-term motivational processes [3,23]. This review addresses this limitation by synthesizing existing studies through an SDT lens to better understand how AI supports sustained, meaningful engagement.

1.5 Problem Statement and Research Gap

Although AI-enhanced Design-Based Learning (DBL) demonstrates strong potential to support motivation through psychological need satisfaction, several critical gaps remain. Much of the existing research is atheoretical, with a predominant focus on short-term learning outcomes rather than sustained motivational development [3,23]. This limits the ability to explain how AI contributes to deeper, long-term engagement.

Empirical evidence within DBL contexts is also limited, particularly in understanding how AI influences autonomy, competence, and creative self-efficacy across iterative design processes

[12,18,21]. While AI has been shown to improve performance and support self-regulated learning, its impact on intrinsic motivation and sustained engagement remains insufficiently explored [4,22].

Additionally, the effectiveness of AI is inconsistent, as outcomes are highly dependent on pedagogical design and levels of learner agency [20]. Issues such as overreliance on AI, reduced creativity, and superficial learning further highlight the need for more structured and theory-informed integration strategies [13,19].

Theoretical constructs such as heutagogy and AI-supported metacognitive scaffolding show strong conceptual promise but lack robust quantitative validation [3,19]. Consequently, there is a need for a comprehensive, theory-driven framework that explains how AI can effectively support motivation, creativity, and deep learning in DBL environments.

Table 2 summarises the key research gaps identified in the literature, highlighting limitations in theory integration, empirical scope, and the lack of long-term and structured investigation into AI-driven motivation within DBL contexts. The table consolidates these gaps to justify the need for a more robust, SDT-informed framework.

Table 2

Identified research gaps

Area	Current State	Gap Identified
Theory use	Mostly atheoretical	Lack of SDT integration
AI impact	Short-term outcomes	No long-term motivation study
DBL context	Limited	Underexplored
Heutagogy	Conceptual	Lack of quantitative validation
Motivation	Mixed findings	No clear framework

This review addresses these gaps by synthesizing literature at the intersection of AI, DBL, and SDT, proposing a framework that aligns AI integration with psychological need satisfaction. It emphasizes the role of AI as a cognitive partner that enhances, rather than replaces, human learning processes, supporting deeper, self-determined learning and intellectual development.

1.6 Purpose of the Systematic Literature Review

This systematic literature review aims to synthesize and evaluate research on AI integration in Design-Based Learning through the lens of Self-Determination Theory. It examines how AI supports autonomy, competence, and relatedness, and how these factors influence student motivation and engagement [22]. The review also identifies effective AI tools and pedagogical strategies, while highlighting areas requiring further empirical investigation. Additionally, it explores the pedagogical, functional, and organizational roles of AI in DBL to inform the development of structured frameworks for effective implementation [5].

1.7 Research Questions

- i. How is Artificial Intelligence (AI) currently integrated into the iterative stages of Design-Based Learning (DBL)?
- ii. To what extent does AI-enhanced DBL support the satisfaction of learners' psychological needs, namely autonomy, competence, and relatedness?
- iii. What challenges and ethical considerations are associated with the motivational impact of AI integration in design education?

2. Methodology

This study adopts a systematic literature review (SLR) to synthesize empirical evidence on the integration of Artificial Intelligence (AI) in Design-Based Learning (DBL), guided by Self-Determination Theory (SDT). The approach addresses the largely atheoretical nature of existing research and the limited examination of motivational mechanisms in AI-enhanced learning environments [3,12].

To ensure rigor, transparency, and replicability, the review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, which provide a structured process for identifying, screening, and synthesizing relevant studies. This approach minimizes selection bias and aligns with established practices in AI in education research [14,20]. The review process includes systematic database searching, application of inclusion and exclusion criteria, and thematic synthesis based on SDT constructs; autonomy, competence, and relatedness which is to examine the psychological impacts of AI in DBL contexts [11,15].

2.1 Research Design

This study employs a systematic literature review to consolidate knowledge at the intersection of AI, DBL, and SDT. The PRISMA framework ensures a transparent and structured selection process, enabling unbiased identification and reporting of relevant empirical studies. The review began with a comprehensive search, followed by a multi-stage screening process. This design supports the analysis of both cognitive and motivational dimensions of AI-supported learning in higher education while also identifying emerging trends and gaps in human-AI interaction [1,24]. From an initial pool of 254 records, 69 articles were retained after screening for relevance. Following eligibility assessment, 16 studies met all inclusion criteria and were included in the final synthesis [25].

2.2 Search Strategy and Information Sources

A systematic search was conducted across Scopus and Web of Science to ensure comprehensive coverage of educational, psychological, and technological domains [3,26]. The search was limited to peer-reviewed journal articles published between 2019 and 2025 to capture recent developments in AI integration.

Keywords related to artificial intelligence (AI), Design-Based Learning (DBL), Self-Determination Theory (SDT), and motivation were combined using Boolean operators to refine the results. Searches were performed across titles, abstracts, and keywords to maximize the retrieval of relevant studies [1,26]. The initial search yielded 254 records, which were subsequently screened to identify studies specifically addressing the intersection of AI, DBL, and SDT, ensuring both breadth and relevance [23].

Table 3 summarizes the search strategy and information sources used in this study, including the selected databases, timeframe, keywords, and search techniques applied to ensure a systematic and replicable literature review process. The table provides a structured overview of how relevant studies were identified and filtered.

Table 3
Search strategy and information sources

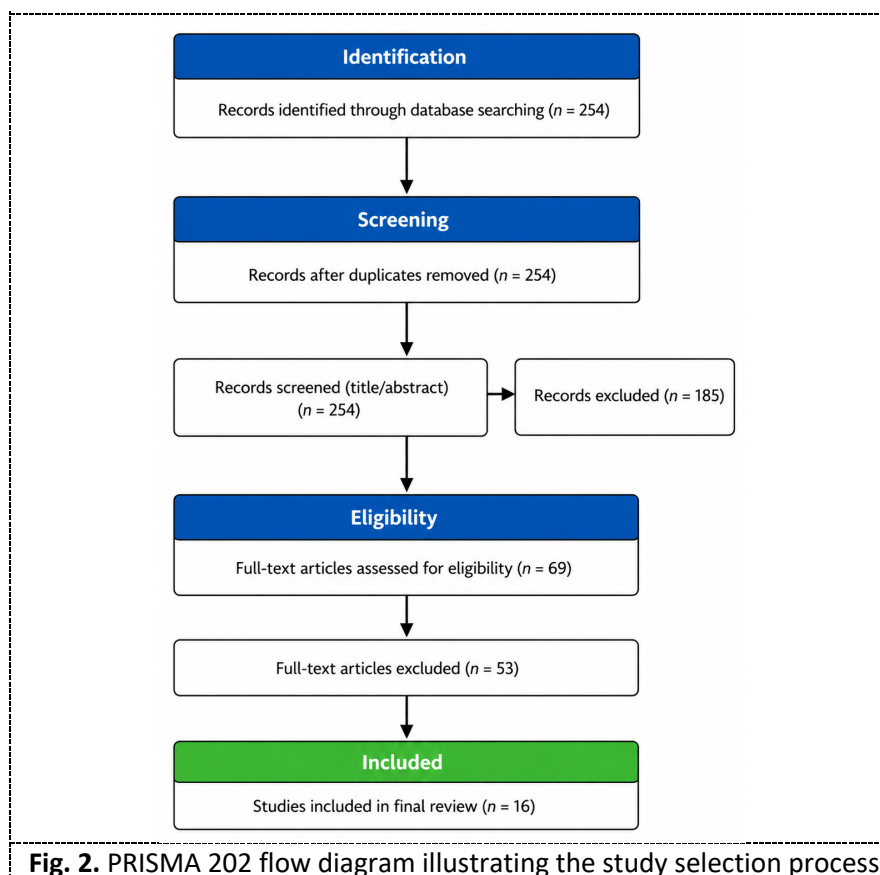
Component	Description
Databases	Scopus, Web of Science
Timeframe	2019–2025
Keywords	“Artificial Intelligence”, “Generative AI”, “Design-Based Learning”, “Self-Determination Theory”, “Motivation”

Search Technique	Boolean operators (AND, OR, NOT), truncation, wildcard
Search Fields	Title, Abstract, Keywords

The initial search yielded 254 records. Subsequent screening refined the dataset to studies specifically addressing the intersection of AI, DBL, and SDT, ensuring both breadth and relevance [23].

2.3 Inclusion and Exclusion Criteria

Explicit inclusion and exclusion criteria were applied to ensure the quality, relevance, and methodological rigor of the selected studies. The studies included were limited to peer-reviewed journal articles that examined AI integration within Design-Based Learning (DBL) contexts and demonstrated alignment with Self-Determination Theory (SDT), using empirical research designs. Studies were excluded if they lacked a clear pedagogical focus or did not explicitly address AI, DBL, or SDT. In addition, non-peer-reviewed publications such as editorials, book chapters, and dissertations were excluded to maintain academic rigor [3]. Non-English publications and grey literature were also omitted to ensure consistency in analysis and interpretation. The study selection process followed a systematic approach based on the PRISMA framework. Figure 2 illustrates the PRISMA 2020 flow diagram, detailing the stages of identification, screening, eligibility, and inclusion. A total of 254 records were initially identified, of which 185 were excluded during the screening stage. 69 full-text articles were assessed for eligibility, resulting in 16 studies being included in the final review.



These criteria ensured that the final dataset comprised studies directly examining the relationship between AI applications and learner motivation in design-oriented educational. Table 4 summarizes the inclusion and exclusion criteria applied in this study. These criteria ensured that only relevant,

high-quality empirical studies focusing on AI applications in DBL and their relationship with learner motivation were retained for analysis.

Table 4
Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles	Editorials, book chapters, dissertations
Language	English	Non-English
Focus	AI in DBL + SDT	Not related to AI, DBL, or SDT
Study Type	Empirical (quantitative, qualitative, mixed)	Conceptual or non-empirical
Scope	Pedagogical focus	No clear educational context

2.4 Data Extraction and Quality Assessment

A structured data extraction process was conducted to capture key information from each study, including educational context, AI tools used, and reported motivational outcomes [11]. The extraction was guided by SDT constructs, focusing on how AI-supported interventions influence autonomy, competence, and relatedness. Quality assessment was performed to evaluate methodological rigor and theoretical alignment [11]. This ensured that only studies providing credible and relevant insights were included in the synthesis.

The combined use of systematic data extraction and quality assessment enabled the identification of patterns, inconsistencies, and research gaps. This approach provides a robust foundation for analyzing the role of AI in shaping motivation and engagement, while supporting the development of a theoretically grounded framework for future research.

3. Results

3.1 AI Integration in the Iterative Stages of DBL

The synthesis indicates that Artificial Intelligence (AI) is embedded across all stages of the Design-Based Learning (DBL) cycle; ideation, prototyping, and evaluation which reshaping traditional learning into a collaborative human-AI process.

During the ideation phase, generative AI tools support brainstorming and concept development, helping learners overcome creative barriers such as “blank page” syndrome [11,12]. This is particularly beneficial for novice learners, as AI enhances divergent thinking and reduces initial cognitive load [27]. In the prototyping stage, AI-driven visualization tools (e.g., Midjourney) enable rapid representation of design concepts, accelerating iteration and improving creative self-efficacy [11]. These tools allow students to explore multiple alternatives efficiently, strengthening confidence in design exploration.

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During the evaluation phase, adaptive AI systems provide real-time, data-driven feedback that supports iterative refinement and reflective learning [8]. This continuous feedback loop enhances design optimization and performance improvement.

Overall, AI shifts DBL from an individual “learning by doing” model to a collaborative “learning by co-doing” paradigm, where AI acts as a co-present agent in ideation, critique, and iteration [25]. However, a critical limitation remains: the ideation-execution gap. While AI effectively supports

conceptual development, it is less capable of facilitating the technical and embodied aspects of design execution [27]. This highlights the need for hybrid pedagogical approaches that combine AI-supported ideation with hands-on learning.

Table 5 summarises the integration of AI across the key stages of the DBL cycle, highlighting corresponding learning impacts and their alignment with Self-Determination Theory (SDT) dimensions. The table demonstrates that AI not only supports different phases of the design process but also contributes to autonomy, competence, and relatedness in distinct ways, reinforcing its role as both a cognitive and collaborative agent. These findings directly address RQ1 by illustrating how AI is systematically embedded across the DBL cycle.

Table 5

AI integration across DBL stages and its impact

DBL Stage	AI Application	Learning Impact	SDT Dimension
Ideation	Generative AI (text/image tools)	Enhances creativity, reduces cognitive barriers	Autonomy
Prototyping	Visualization tools (e.g., Midjourney)	Improves exploration and creative confidence	Competence
Evaluation	Adaptive feedback systems	Supports iteration and reflective learning	Competence
Across stages	AI as co-agent	Enables collaborative cognition	Relatedness
DBL Stage	AI Application	Learning Impact	SDT Dimension

Overall, AI shifts DBL from an individual “learning by doing” model to a collaborative “learning by co-doing” paradigm, where AI acts as a co-present agent in ideation, critique, and iteration [25]. However, a critical limitation remains: the ideation-execution gap. While AI effectively supports conceptual development, it is less capable in facilitating the technical and embodied aspects of design execution [27]. This highlights the need for hybrid pedagogical approaches combining AI-supported ideation with hands-on learning. These findings directly address RQ1 by demonstrating that AI is systematically embedded across all stages of the DBL cycle, functioning as both a cognitive and collaborative agent.

3.2 Impact on Basic Psychological Needs

3.2.1 Autonomy

AI enhances autonomy by enabling personalized learning pathways and flexible pacing, allowing learners to control their learning processes [8,15]. It also supports divergent thinking by offering multiple solution pathways, empowering learners to make independent design decisions. Adaptive scaffolding further strengthens self-directed learning by adjusting support based on learner progress. However, autonomy is conditional on AI literacy. Without critical evaluation skills, learners risk becoming passive consumers of AI outputs. Excessive reliance may reduce independent problem-solving and weaken true autonomy [28].

3.2.2 Competence

AI strongly supports competence through adaptive feedback, scaffolding, and personalized learning experiences [9,29]. By aligning task difficulty with learner ability, AI maintains an optimal challenge level, reinforcing perceived mastery and intrinsic motivation [23]. AI-driven analytics further enhance competence by identifying learning gaps and enabling targeted interventions [1]. In

DBL contexts, AI also supports collective competence, facilitating shared problem-solving and collaborative learning [22].

3.2.3 Relatedness

The role of AI in relatedness is more nuanced. While direct human-AI relationships remain emergent, AI supports relatedness by facilitating collaboration and socially shared learning [17]. AI-mediated interaction enables co-creation, shared regulation, and group engagement, extending relatedness beyond human interaction to human-AI-human collaboration. However, overreliance on AI particularly in early creative stages, may weaken the development of iterative learning skills and long-term creativity [13]. A balance between AI support and human interaction is therefore essential. Overall, the findings indicate that AI most strongly supports competence and autonomy, while its contribution to relatedness remains emerging and context dependent.

3.3 Challenges and Ethical Considerations

Despite its benefits, AI integration presents several critical challenges. The identified challenges can be broadly categorized into cognitive, ethical, and pedagogical risks. Key issues include:

- i. Atheoretical research foundations, limiting understanding of motivational mechanisms [3].
- ii. Algorithmic bias, potentially reinforcing educational inequities [30].
- iii. Cognitive offloading, reducing deep learning and critical thinking [28]
- iv. Academic integrity concerns, especially with generative AI
- v. Overreliance on AI may undermine autonomy and self-efficacy by reducing active cognitive engagement [4].

Ethical concerns also extend to:

- i. Data privacy and surveillance
- ii. Lack of transparency in AI systems
- iii. Risk of surface-level learning

These findings highlight the need for structured, ethically grounded AI integration, supported by governance frameworks that ensure fairness, inclusivity, and meaningful learning outcomes [22], [31].

3.4 Emerging Trends and Future Trajectories

Emerging trends indicate a shift toward “Aidemics”, characterized by a symbiotic relationship between human and AI in education [9]. A key development is the Human-Centered AI Pedagogical Engagement framework, which emphasizes ethical AI integration and preservation of human agency [9]. This aligns with SDT by prioritizing autonomy, usability, and meaningful engagement [4]. At the same time, agentic AI and adaptive systems are gaining prominence for enabling personalized and engaging learning experiences [1]. To mitigate risks of superficial learning, heutagogical approaches are increasingly advocated. These approaches promote self-determined learning and metacognitive regulation, ensuring deeper engagement aligned with SDT [19]. Future research priorities:

- i. Longitudinal studies on motivation and creativity
- ii. Empirical validation of AI-supported heutagogy
- iii. Ethical frameworks addressing bias, privacy, and dependency

4. Conclusions

This systematic review demonstrates that AI is deeply embedded across all stages of Design-Based Learning, transforming it into a collaborative human-AI process. AI enhances ideation, accelerates prototyping, and strengthens evaluation through adaptive feedback, contributing to improved motivation and creative self-efficacy. From a Self-Determination Theory perspective, AI:

- i. Supports autonomy through personalized and flexible learning
- ii. Enhances competence via adaptive scaffolding and feedback
- iii. Facilitates relatedness through collaborative and socially shared learning

However, these benefits are moderated by critical challenges, including cognitive offloading, algorithmic bias, ethical concerns, and the atheoretical nature of existing research. The findings emphasize that AI should function as a cognitive partner rather than a replacement for human learning. Without careful pedagogical design, there is a risk of superficial engagement and diminished learner agency. Future research must prioritize longitudinal, theory-driven, and ethically grounded approaches to ensure that AI-enhanced DBL supports deep learning, sustained motivation, and meaningful educational transformation.

Acknowledgement

This research was not funded by any grant.

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