

Effect of Ai-Driven Project-Based Learning on Interior Design Students’ Creative Behaviour: Suzhou Vocational College, Jiangsu Province

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Receive December 6, 2025; Retrieved December 25, 2025; Accepted March 12, 2026

Abstract

This study examines the effects of Artificial Intelligence–Driven Project-Based Learning (AI-PBL) on students’ learning engagement and creative idea generation in interior design education. It further investigates the mediating role of learning engagement—conceptualized as absorption, dedication, and vigor—and the moderating role of creative self-efficacy in the relationship between AI-PBL and creative ideation behavior. The purpose of the study is to clarify the psychological mechanisms through which AI-enhanced instructional approaches support creativity in higher education.

A mixed-methods research design was employed. Quantitative data were collected through a cross-sectional questionnaire administered to university students with experience in AI-supported project-based learning and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). In addition, qualitative data were obtained from semi-structured interviews with instructors experienced in implementing AI-PBL to enrich the interpretation of the quantitative findings.

The results indicate that AI-PBL has a significant positive effect on all three dimensions of learning engagement: absorption, dedication, and vigor. Learning engagement was found to partially mediate the relationship between AI-PBL and creative idea generation, highlighting its critical role in fostering innovative thinking. Furthermore, creative self-efficacy significantly moderates the relationship between learning engagement and creative ideation, with higher levels of self-efficacy strengthening the positive impact of engagement on creative performance. Qualitative findings support these results, emphasizing the importance of personalized guidance, collaborative interaction, and immediate feedback in AI-PBL

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environments. Overall, the study provides empirical support for integrating AI-driven pedagogical strategies to enhance student creativity through engagement-oriented learning design.

Keywords: AI-PBL, Learning Engagement, Creative Idea Generation, Creative Self-Efficacy

Introduction

Over the past decade, rapid global economic development, technological advancement, and socio-cultural transformation have profoundly reshaped the interior design industry. The field has evolved from a traditional focus on aesthetic spatial decoration to integrated, human-centered design solutions that encompass user experience, sustainability, smart systems, and cultural expression (AlShkipi, A. A. & Zahran, B., 2024). Despite this substantial industrial transformation, interior design education at the higher education level continues to face a significant misalignment with contemporary industry demands, particularly in relation to commercial awareness, entrepreneurial competence, project management, and advanced technical skills.

This mismatch reflects structural limitations within traditional interior design curricula, which predominantly emphasize craftsmanship and individual aesthetic judgment rather than systems thinking, collaborative problem-solving, and evidence-based design processes (Lee, Y. & Paul, A., 2023; Somthawinpongchai, C. et al., 2022). As a result, graduates often lack the competencies required to operate effectively within complex professional environments. This skills gap has contributed to productivity constraints within architecture, engineering, and construction (AEC) sectors, generating measurable economic impacts and underscoring the urgent need for educational reform to enhance innovation capacity and workforce readiness.

At the same time, the rapid advancement of information technology—particularly artificial intelligence (AI)—has begun to transform higher education fundamentally. AI has expanded beyond administrative support functions to become a critical driver of instructional innovation (Hamal, S. et al., 2022). However, the application of AI in design education remains contested, as concerns persist regarding the potential erosion of human creativity if AI technologies are implemented without appropriate pedagogical frameworks. Consequently, a key educational challenge lies in designing learning models that leverage the analytical and



computational strengths of AI while preserving and enhancing the unique creative capacities of human designers (Somthawinpongsai, C. et al., 2025).

Project-Based Learning (PBL) has been widely recognized as an effective pedagogical approach for fostering critical thinking, collaboration, and creativity through engagement with authentic or simulated real-world problems (Gunarathna, C. et al., 2024). Nevertheless, existing studies have largely examined PBL in general educational contexts, offering limited insight into how the integration of AI within PBL environments influences students' learning engagement and creative ideation—particularly in interior design education, where creative ideation constitutes the foundation of the design process (Lee, J. H. & Ostwald, M. J., 2022).

Moreover, although prior research has established the importance of learning engagement and creative self-efficacy in shaping creative outcomes, empirical investigations into these relationships within AI-mediated learning environments remain scarce. Specifically, there is a lack of systematic examination of how AI-enhanced project-based learning influences students' absorption, dedication, and vigor, and how these dimensions of engagement subsequently affect creative ideation behavior (Bandura, A. 1997; Cai, Y. et al., 2023). In addition, the moderating role of creative self-efficacy in AI-driven educational contexts has yet to be sufficiently explored, particularly through the lens of social cognitive theory and constructivist learning theory in human-machine collaborative settings (Somthawinpongsai, C. et al., 2025).

In response to these gaps, the present study addresses a critical need to develop and empirically examine an AI-driven project-based learning framework for interior design education. By investigating the relationships among AI-driven PBL, learning engagement, creative ideation behavior, and creative self-efficacy, this research contributes to the theoretical advancement of creative learning in AI-enhanced environments. Furthermore, the findings are expected to provide practical guidance for curriculum innovation and instructional design, supporting the cultivation of interior design graduates who possess both advanced creative competencies and professional readiness aligned with evolving industry demands.

Objective

The objectives of this study are:

1. To examine the effects of AI-driven project-based learning on students' learning engagement (absorption, dedication, and vigor) in interior design education.



2. To investigate the relationship between learning engagement and creative ideation behavior in AI-enhanced learning environments.

3. To test the moderating role of creative self-efficacy in the relationship between learning engagement and creative ideation behavior.

Review of Literature and Ideas

The rapid advancement of artificial intelligence (AI) has significantly reshaped pedagogical practices in higher education, particularly in design-related disciplines. In interior design education, AI is increasingly integrated into project-based learning (PBL) environments to support information processing, visual ideation, and iterative design development. AI-driven project-based learning (AI-PBL) extends traditional PBL by embedding intelligent tools that reduce cognitive load associated with repetitive tasks and enable learners to focus on higher-order thinking and creative problem-solving (Hamal, S. et al., 2022). Prior studies indicate that learner-centered and technology-enhanced PBL environments promote active engagement and meaningful learning experiences (Gunarathna, C. et al., 2024).

Learning engagement is a key psychological mechanism explaining how instructional approaches influence learning outcomes. Drawing on the Utrecht Work Engagement framework, learning engagement consists of three dimensions: absorption, dedication, and vigor (Schaufeli, W. B. et al., 2006). In design education, these dimensions are particularly relevant due to the cognitively demanding and iterative nature of creative tasks. Empirical evidence suggests that project-based and AI-supported learning environments enhance students' cognitive immersion, emotional commitment, and sustained learning energy (Lee, Y. & Paul, A., 2023). Accordingly, AI-PBL is expected to positively influence students' absorption, dedication, and vigor.

Creative ideation represents the core of the interior design process and involves the generation and development of novel and useful ideas. Research in creativity and design studies consistently demonstrates that students with higher levels of learning engagement are more likely to persist in complex problem-solving, explore alternative solutions, and produce more innovative ideas (Lee, J. H. & Ostwald, M. J., 2022). Thus, each dimension of learning engagement is theoretically linked to creative ideation behavior in AI-enhanced learning contexts.



From a constructivist perspective, instructional methods influence learning outcomes indirectly through learners' psychological states. In AI-PBL environments, AI tools do not directly generate creativity; instead, they shape students' engagement with learning tasks. Learning engagement, therefore, functions as a mediating variable through which AI-PBL affects creative ideation behavior (Cai, Y. et al., 2023). Furthermore, creative self-efficacy defined as individuals' beliefs in their ability to produce creative outcomes—plays a critical role in creative performance. According to social cognitive theory, self-efficacy influences persistence, effort, and the effective use of available resources (Bandura, A., 1997). In AI-enhanced learning environments, students with higher creative self-efficacy are more likely to actively leverage AI tools to support idea exploration rather than rely on them passively. Consequently, creative self-efficacy is expected to moderate the relationship between learning engagement and creative ideation.

Based on the reviewed literature, this study proposes a conceptual framework in which AI-driven project-based learning influences creative ideation behavior through the mediating effects of learning engagement (absorption, dedication, and vigor), with creative self-efficacy moderating the relationships between learning engagement and creative ideation.

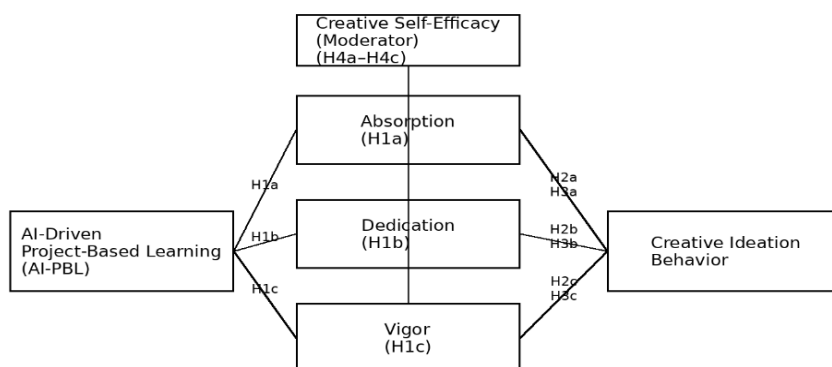


Figure 1 Conceptual framework of the study.

Research scope

This study examines the effects of artificial intelligence-driven project-based learning (AI-PBL) on students' learning engagement and creative ideation behavior within interior design education. Learning engagement is conceptualized through three dimensions: absorption, dedication, and vigor—based on the work engagement framework (Schaufeli, W. B. et al.,



2006). Creative ideation behavior is investigated as the primary learning outcome, while creative self-efficacy is included as a moderating variable influencing the relationship between learning engagement and creative ideation, grounded in social cognitive theory (Bandura, A., 1997).

The population of this study is limited to interior design students who have direct experience using AI tools in project-based learning activities. Methodologically, the research is confined to a mixed-methods approach, with quantitative data analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine direct, mediating, and moderating effects, and qualitative data used to support interpretation of the findings. The scope of this study is restricted to educational settings and does not extend to professional design practice or other design disciplines.

Research Methodology

This study adopts a mixed-methods research design grounded in a pragmatist paradigm to comprehensively examine the relationships among artificial intelligence-driven project-based learning (AI-PBL), learning engagement, creative ideation behavior, and creative self-efficacy in interior design education (Creswell, J. W. & Plano Clark, V. L., 2018). The integration of quantitative and qualitative methods enables both hypothesis testing and deeper interpretation of learning mechanisms.

The quantitative phase employs a cross-sectional survey design. Data are collected using a structured questionnaire measuring AI-PBL experience, learning engagement (absorption, dedication, and vigor), creative ideation behavior, and creative self-efficacy. Measurement items are adapted from established scales to ensure construct validity (Bandura, A., 1997; Schaufeli, W. B. et al., 2006). Data analysis is conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine direct effects, mediating effects of learning engagement, and moderating effects of creative self-efficacy, which is appropriate for complex models and exploratory theory development (Hair, J. F. et al., 2017).

The qualitative phase employs semi-structured interviews with instructors experienced in AI-driven project-based learning. This phase aims to explore educators' perceptions of students' engagement and creative ideation processes in AI-enhanced learning environments. Qualitative findings are used to support, clarify, and enrich the interpretation of quantitative results through thematic analysis (Braun, V. & Clarke, V., 2006).



Overall, the mixed-methods approach enhances the validity, explanatory power, and practical relevance of the research by triangulating statistical relationships with contextual insights from instructional practice.

Results

The mediation analysis confirms that learning engagement significantly mediates the relationship between AI-PBL and creative ideation behavior. Specifically, Absorption, Dedication, and Vigor each function as significant mediators, supporting hypotheses H3a, H3b, and H3c. These findings indicate that AI-PBL influences creative ideation indirectly by enhancing students' psychological engagement across cognitive, affective, and motivational dimensions.

Moderating Role of Creative Self-Efficacy

Moderation analysis shows that creative self-efficacy significantly moderates the relationships between learning engagement and creative ideation behavior. The interaction effects between creative self-efficacy and Absorption ($\beta = 0.18$, $t = 3.45$, $p = 0.001$), Dedication ($\beta = 0.22$, $t = 4.12$, $p < 0.001$), and Vigor ($\beta = 0.15$, $t = 2.97$, $p = 0.003$) are all positive and statistically significant.

These results support hypotheses H4a, H4b, and H4c, indicating that students with higher creative self-efficacy experience a stronger positive effect of learning engagement on creative ideation behavior. This suggests that creative self-efficacy enhances students' ability to effectively leverage AI-supported learning environments for creative idea generation.

Summary of Hypotheses Testing

Overall, the empirical findings confirm all proposed hypotheses (H1a–H4c). AI-driven project-based learning positively affects learning engagement, which in turn promotes creative ideation behavior. Learning engagement serves as a key mediating mechanism, while creative self-efficacy strengthens the impact of engagement on creativity. Together, these results provide strong empirical support for the proposed conceptual framework and highlight the psychological mechanisms through which AI-PBL enhances creative outcomes in interior design education.



Table 1 Summary of Hypotheses Testing Results

Hypothesis	Structural Path	Statistical Result	Conclusion
H1a	AI-PBL → Absorption	$\beta = 0.52, p < .001$	Supported
H1b	AI-PBL → Dedication	$\beta = 0.61, p < .001$	Supported
H1c	AI-PBL → Vigor	$\beta = 0.48, p < .001$	Supported
H2a	Absorption → Creative Ideation	$\beta = 0.35, p < .001$	Supported
H2b	Dedication → Creative Ideation	$\beta = 0.42, p < .001$	Supported
H2c	Vigor → Creative Ideation	$\beta = 0.29, p < .001$	Supported
H3a	AI-PBL → Absorption → Creative Ideation	Significant mediation	Supported
H3b	AI-PBL → Dedication → Creative Ideation	Significant mediation	Supported
H3c	AI-PBL → Vigor → Creative Ideation	Significant mediation	Supported
H4a	Creative Self-Efficacy × Absorption → Creative Ideation	$\beta = 0.18, p = .001$	Supported
H4b	Creative Self-Efficacy × Dedication → Creative Ideation	$\beta = 0.22, p < .001$	Supported
H4c	Creative Self-Efficacy × Vigor → Creative Ideation	$\beta = 0.15, p = .003$	Supported

Concussion, Discussion, Suggestion

The findings of this study provide empirical evidence supporting the effectiveness of AI-driven project-based learning (AI-PBL) in enhancing students' learning engagement and creative ideation behavior in interior design education. The results confirm that AI-PBL significantly influences all three dimensions of learning engagement—absorption, dedication, and vigor—thereby validating the proposed engagement-based learning mechanism in AI-enhanced design environments. This finding is consistent with prior studies indicating that technology-enhanced project-based learning environments promote deeper learner engagement by fostering active participation and meaningful task involvement (Gunarathna, C. et al., 2024; Hamal, S. et al., 2022).

First, the positive effects of AI-PBL on learning engagement suggest that the integration of AI tools within project-based learning environments successfully promotes students' cognitive immersion, emotional commitment, and sustained learning energy. This finding aligns with previous research demonstrating that learner-centered and digitally supported instructional approaches enhance engagement by increasing task relevance, learner autonomy, and interactive feedback mechanisms (Lee, Y. & Paul, A., 2023; Schaufeli, W. B.



et al., 2006). In the context of interior design education, AI-supported visualization, rapid prototyping, and iterative feedback create immersive learning experiences that facilitate students' absorption in complex design tasks while strengthening their dedication and enthusiasm for project completion, consistent with flow-based learning research (Munir, H. et al., 2022).

Second, the significant relationships between learning engagement and creative ideation behavior highlight the critical role of engagement as a psychological driver of creativity. Students who demonstrate higher levels of absorption, dedication, and vigor are more likely to persist in ideation tasks, explore alternative design solutions, and generate innovative ideas. This finding supports creativity and design research emphasizing that creative ideation is not solely a function of technical skill or domain knowledge, but is strongly influenced by learners' motivational and affective states (Lee, J. & Ostwald, M., 2022; Lai, Y.-C. et al., 2020). The relatively high explanatory power of learning engagement for creative ideation further underscores its importance as a core mechanism linking instructional design to creative outcomes.

Third, the confirmed mediating role of learning engagement indicates that AI-PBL does not directly enhance creativity in isolation; rather, its impact operates through changes in students' psychological engagement with learning activities. This result reinforces constructivist learning perspectives, which posit that meaningful learning outcomes emerge through active involvement and sustained interaction with learning tasks (Creswell, J. W. & Plano Clark, V. L., 2018). In AI-enhanced learning environments, AI functions as a facilitator that reshapes how students engage cognitively and emotionally with design problems, rather than replacing human creative processes, echoing recent arguments on human-AI collaborative learning (Somthawinpongsai, C. et al., 2025).

Finally, the moderating effects of creative self-efficacy demonstrate that students' beliefs in their creative capabilities play a pivotal role in determining how effectively learning engagement translates into creative ideation behavior. Students with higher creative self-efficacy benefit more from engagement-enhancing learning environments, suggesting that confidence in one's creative ability enables more proactive and strategic use of AI tools for exploration and idea development. This finding extends social cognitive theory into AI-mediated educational contexts and highlights creative self-efficacy as a key psychological



condition for maximizing the creative potential of AI-supported learning (Bandura, A., 1997; Cai, Y. et al., 2023).

Overall, the findings suggest that AI-PBL, learning engagement, and creative self-efficacy operate as an integrated system that supports creative ideation in interior design education. This study contributes to the growing body of literature on AI-enhanced learning by demonstrating that human creativity remains central and is strengthened—not diminished—when AI is embedded within thoughtfully designed, engagement-oriented pedagogical frameworks, supporting calls for human-centered AI in education (Chan, C. K. Y., 2023a)

Knowledge of Research

This study contributes new knowledge to the fields of interior design education and AI-enhanced learning by empirically clarifying the mechanisms through which artificial intelligence-driven project-based learning (AI-PBL) influences students' creative ideation behavior. The findings extend existing research by demonstrating that AI-PBL enhances creativity not directly, but through students' psychological engagement in learning, conceptualized as absorption, dedication, and vigor (Schaufeli, W. B. et al., 2006).

First, this research advances theoretical understanding by integrating learning engagement theory with creative ideation and social cognitive theory within an AI-mediated educational context. While prior studies have examined project-based learning or AI-supported instruction independently, this study provides empirical evidence that learning engagement functions as a key mediating mechanism linking AI-PBL to creative ideation behavior. This finding strengthens constructivist learning perspectives, emphasizing that meaningful creative outcomes emerge from active cognitive and emotional involvement rather than from technological intervention alone (Creswell, J. W. & Plano Clark, V. L., 2018).

Second, the study extends the application of creative self-efficacy theory to AI-enhanced learning environments. The results reveal that creative self-efficacy moderates the relationship between learning engagement and creative ideation behavior, indicating that students' beliefs in their creative abilities shape how effectively engagement translates into innovative outcomes. This contribution expands social cognitive theory by illustrating how self-efficacy operates in human-AI collaborative learning settings (Bandura, A., 1997).



Third, this research contributes methodological knowledge by applying Partial Least Squares Structural Equation Modeling (PLS-SEM) to simultaneously examine direct, mediating, and moderating effects in design education research. The integrated mixed-methods approach further enhances explanatory depth by triangulating statistical findings with qualitative insights, providing a robust framework for future studies investigating complex learning mechanisms in AI-supported educational contexts (Hair, J. F. et al., 2017).

Overall, this study enriches the existing body of knowledge by positioning AI-PBL, learning engagement, and creative self-efficacy as an interdependent system that supports creative ideation in interior design education. It underscores the principle that AI functions most effectively as a catalyst for learning when embedded within human-centered, engagement-oriented pedagogical designs, thereby reinforcing the central role of human creativity in the era of artificial intelligence (Chan, C. K. Y., 2023b).

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