Constructing a Case Teaching Model for Packaging Design Courses in the Era of Generative AI

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ABSTRACT

Generative artificial intelligence (GAI) is transforming design education by reshaping how design knowledge is generated, explored, and applied. While previous studies have primarily examined AI-assisted creativity and curriculum innovation, comparatively limited attention has been devoted to reconstructing case teaching for AI-supported learning. Addressing this gap, this study proposes the Generation–Analysis–Iteration–Reflection (GAIR) pedagogical model for packaging design education. Drawing upon literature on generative AI, case-based learning, and design pedagogy, the study first analyses the challenges that AI presents for traditional case teaching before developing a process-oriented pedagogical framework centred on human–AI collaboration. The GAIR model reconceptualises design cases as evolving pedagogical resources that accompany the entire learning process rather than static instructional examples. Through the four interconnected stages of Generation, Analysis, Iteration, and Reflection, students progressively develop creative exploration, design reasoning, design optimisation, and design judgement. The study contributes to the literature by extending case-based learning to AI-assisted design education and provides a practical framework for curriculum design, teacher facilitation, and formative assessment in packaging design courses. The proposed model also offers a theoretical foundation for future empirical research on AI-assisted case teaching in studio-based design education.

Keywords: Generative Artificial Intelligence (GAI), Packaging Design Education, Case-Based Learning, Human–AI Collaboration, Design Pedagogy

INTRODUCTION

Background

The emergence of generative artificial intelligence (GAI) is reshaping the ways in which knowledge is created, accessed, and applied across higher education. Unlike earlier generations of educational technologies that primarily supported information retrieval or instructional delivery, generative AI enables learners to actively generate content, explore alternative solutions, and engage in iterative knowledge construction through continuous interaction with intelligent systems. This shift has prompted educators to reconsider not only how students learn, but also how learning activities should be organised to foster higher-order thinking, creativity, and critical judgement in AI-supported environments, particularly in practice-oriented disciplines where learning relies heavily on creative problem solving and iterative design processes (UNESCO, 2023; Sharples, 2023).

The implications of this transformation are particularly evident in design education, where learning is inherently exploratory, practice-based, and centred on solving ill-defined problems, characteristics that have long been recognised as fundamental to designerly ways of knowing (Cross, 2006). Recent studies suggest that generative AI is changing conventional design workflows by enabling rapid visualisation, concept generation, and human–AI co-creation, thereby extending the range of creative possibilities available to learners (Meron and Tekmen Araci, 2023). Rather than functioning solely as a digital production tool, generative AI increasingly participates in the design process as an interactive collaborator capable of supporting ideation, experimentation, and iterative refinement. As a result, design learning is gradually shifting from a linear sequence of problem solving towards a more dynamic process of exploration, evaluation, and continuous revision. These changes are particularly influential in studio-based disciplines such as packaging design, where iterative design exploration forms an essential component of learning.

This pedagogical transformation is especially significant in packaging design education. Packaging design requires students to integrate branding, visual communication, structural design, material selection, sustainability, consumer experience, and market positioning within authentic design projects. Unlike many other design disciplines, packaging design demands that aesthetic expression be continuously balanced with functional, commercial, and manufacturing constraints. The availability of generative AI allows students to rapidly produce and compare multiple packaging concepts under different design requirements, substantially expanding opportunities for creative exploration. At the same time, the ease with which design alternatives can be generated challenges traditional teaching approaches that rely primarily on analysing a limited number of instructor-selected cases. Consequently, the central issue facing packaging design education is no longer whether generative AI should be incorporated into teaching, but how pedagogical approaches should be redesigned to support meaningful learning through human–AI collaboration.

Current Research

Recent research has established that generative artificial intelligence is no longer viewed merely as an emerging educational technology but as a catalyst for pedagogical transformation in higher education. Early studies primarily examined AI as a tool for automating instructional tasks and supporting personalised learning, whereas more recent research has shifted towards redesigning learning environments in response to human–AI collaboration. Current discussions increasingly emphasise that the educational impact of generative AI depends less on technological capability itself than on how teaching strategies, curriculum design, and assessment practices are reconfigured to accommodate AI-assisted learning (Kasneci et al., 2023; Zawacki-Richter et al., 2019). This evolving perspective provides an important foundation for reconsidering pedagogical approaches in design education.

Within design education, generative AI has attracted growing attention for its capacity to support concept generation, visual exploration, design ideation, and iterative creative development. Rather than replacing designers, AI is increasingly understood as a collaborative partner capable of facilitating human creativity throughout the design process (Meron and Tekmen Araci, 2023). Consequently, recent studies have argued that design education should move beyond teaching students how to use AI tools towards cultivating critical judgement, creative decision-making, and reflective thinking in AI-supported design environments. These discussions indicate that technological integration alone is insufficient; meaningful pedagogical innovation remains essential for developing students' long-term design competence.

Research focusing specifically on packaging design education has likewise begun to respond to these technological developments. Existing studies have explored curriculum development, competency-based learning outcomes, and teaching reform within packaging programmes, highlighting the interdisciplinary nature of packaging education and its emphasis on integrating visual communication, structural design, materials, sustainability, and market-oriented thinking (Auras et al., 2023). Recent studies on packaging design education have further suggested that artificial intelligence offers new opportunities for packaging design teaching by supporting creative exploration, improving instructional efficiency, and enriching students' design experiences. At the same time, these studies also recognise that the adoption of AI requires corresponding adjustments to teaching organisation and curriculum implementation rather than simply introducing new digital tools into existing courses.

Meanwhile, case-based learning continues to be recognised as one of the most influential pedagogical approaches in design education because it enables students to engage with authentic design problems, analyse professional decision-making processes, and connect theoretical knowledge with practical application (Merseth, 1991). Through the examination of real design situations, learners are encouraged to compare alternative solutions, justify design decisions, and develop reflective judgement. However, the majority of existing studies on case teaching were developed before the widespread adoption of generative AI and therefore implicitly assume that design cases are selected, organised, and interpreted by instructors. Comparatively little attention has been devoted to how the pedagogical role of design cases may evolve when students actively generate, analyse, refine, and reinterpret cases through continuous interaction with generative AI.

Research Gap

Despite the growing body of research on generative AI in higher education and design education, several important limitations remain. Existing studies have substantially advanced our understanding of AI-assisted creativity, curriculum innovation, and human–AI collaboration, providing valuable insights into how emerging technologies can support teaching and learning. These contributions have laid an important foundation for integrating generative AI into design education and have demonstrated its potential to transform creative practice as well as instructional delivery.

However, the majority of existing studies approach generative AI primarily from a technological perspective, focusing on what AI can generate or how AI tools can be incorporated into existing teaching activities. Comparatively less attention has been devoted to how pedagogical approaches themselves should be redesigned to respond to AI-assisted learning. In particular, although case teaching has long been recognised as an important instructional approach in design education, current research rarely examines how the pedagogical functions of design cases may change when students actively participate in generating, analysing, refining, and reflecting upon cases with the assistance of generative AI. As a consequence, existing case teaching continues to rely predominantly on instructor-selected examples and product-oriented analysis, which are increasingly insufficient for supporting AI-assisted design learning characterised by continuous interaction, rapid iteration, and collaborative knowledge construction.

This limitation is especially evident in packaging design education. Compared with other design disciplines, packaging design requires students to balance aesthetic creativity with functional performance, branding, sustainability, manufacturability, and market considerations within authentic design contexts. The widespread adoption of generative AI has fundamentally changed how packaging concepts are generated, compared, and refined throughout the design process, thereby challenging conventional approaches to case teaching that position students primarily as recipients of expert knowledge rather than active constructors of design knowledge. Nevertheless, a systematic pedagogical model capable of integrating generative AI with process-oriented case teaching in packaging design courses has yet to be established. Addressing this gap requires a pedagogical model that reconceptualises case teaching for AI-assisted packaging design education, which constitutes the primary objective of the present study.

Research Objective and Contributions

To address the research gap identified above, this study aims to develop a process-oriented case teaching model for packaging design courses in the context of generative artificial intelligence. Rather than viewing AI merely as a tool for improving design efficiency, this study conceptualises generative AI as a catalyst for pedagogical transformation and explores how case teaching can be systematically reconstructed to support AI-assisted learning. Drawing upon recent advances in AI-assisted education, design pedagogy, and case-based learning, the study proposes the Generation–Analysis–Iteration–Reflection (GAIR) model as a pedagogical framework that reorganises case teaching around the continuous construction of design knowledge through human–AI collaboration.

This study makes three contributions to the existing literature.

First, it contributes to design pedagogy by identifying the new pedagogical challenges that generative AI introduces to case teaching in packaging design education. Rather than focusing exclusively on technological applications, the study demonstrates why traditional product-oriented case teaching is increasingly inadequate for supporting process-oriented AI-assisted design learning.

Second, it contributes to the theoretical development of case-based learning by reconceptualising the educational role of design cases. The proposed GAIR model views design cases not as static instructional resources selected by teachers but as evolving learning resources that are continuously generated, analysed, refined, and reflected upon throughout the design process. In doing so, the study extends existing understandings of case teaching from a product-oriented instructional approach to a process-oriented pedagogical model.

Finally, the study provides a practical pedagogical framework for packaging design education in the era of generative AI. The GAIR model offers systematic guidance for organising case teaching, facilitating human–AI collaboration, and supporting process-oriented learning, thereby providing a pedagogical reference for curriculum redesign, instructional practice, and assessment reform in AI-assisted packaging design education.

Challenges Of Case Teaching In Packaging Design Courses Under Generative Ai

Generative AI reshapes design learning

The widespread adoption of generative artificial intelligence has fundamentally transformed the nature of design learning. Unlike conventional digital technologies that primarily support information retrieval or technical execution, generative AI actively participates in creative processes by generating design concepts, visual representations, and alternative solutions through human–AI collaboration. As a result, students are no longer limited to learning from predefined design knowledge or teacher-selected examples but are increasingly engaged in an interactive learning process characterised by exploration, evaluation, and continuous refinement. Recent studies have consistently argued that generative AI is reshaping higher education by promoting personalised learning, enhancing creative productivity, and enabling more dynamic knowledge construction (Kasneci et al., 2023; Dwivedi et al., 2023; UNESCO, 2023). In design disciplines, these characteristics are particularly influential because design learning is inherently iterative, practice-oriented, and centred on creative problem solving. Consequently, the integration of generative AI should not be regarded merely as the introduction of a new technological tool but as a transformation of the underlying learning paradigm.

One of the most significant changes introduced by generative AI lies in the way design knowledge is acquired and constructed. Traditionally, students developed design competence primarily through lectures, textbooks, instructor demonstrations, and carefully selected design cases. Learning was largely based on understanding existing design solutions before gradually applying acquired knowledge to new projects. Generative AI has fundamentally expanded this learning process by allowing students to instantly generate multiple design alternatives, compare diverse visual expressions, and receive immediate feedback during concept development. Rather than passively receiving knowledge, students are increasingly involved in an active process of questioning, generating, evaluating, and revising design ideas. Existing studies have suggested that AI-assisted learning environments encourage exploratory learning and support more personalised learning experiences by enabling students to interact with knowledge in a flexible and iterative manner (Holmes et al., 2019; Zawacki-Richter et al., 2019). For packaging design education, this means that learning resources are no longer confined to existing teaching materials; instead, AI-generated content becomes an integral component of students' design exploration.

Limitations of traditional case teaching

Traditional case teaching has long been regarded as one of the most effective pedagogical approaches in design education because it enables students to connect theoretical knowledge with authentic design practice. Rather than simply transmitting knowledge, case teaching encourages learners to analyse design problems, interpret professional decision-making, and develop reflective thinking through the examination of real-world cases. Experiential learning theory suggests that meaningful learning occurs through the continuous cycle of concrete experience, reflective observation, conceptualisation, and active experimentation (Kolb, 1984). Similarly, Schön (1983) argues that professional competence in design is cultivated through reflective practice, in which learners critically examine design decisions rather than merely imitate design outcomes. These perspectives provide the theoretical foundation for case-based learning in design education, where carefully selected cases have traditionally served as important learning resources for developing students' design thinking and professional judgement. Within this pedagogical paradigm, teachers play a central role in selecting representative cases, interpreting design processes, and guiding students to construct disciplinary knowledge through structured analysis.

However, the emergence of generative AI has fundamentally altered the pedagogical role of design cases. In traditional case teaching, design cases are relatively stable instructional resources selected, organised, and interpreted by instructors before being presented to students for analysis and discussion. Students primarily acquire design knowledge by examining completed design works and understanding the design decisions embedded within them. Under AI-assisted design learning, however, students are able to generate multiple design alternatives independently through iterative interactions with generative AI systems. Design cases are therefore no longer limited to teacher-selected examples; instead, they become dynamic learning artefacts that continuously evolve throughout the design process. Consequently, the relationship between learners and design cases shifts from passive observation to active construction, while the role of design cases expands from illustrating existing knowledge to facilitating ongoing design exploration, evaluation, and refinement. This transformation challenges one of the fundamental assumptions of traditional case teaching—that effective learning is primarily achieved through analysing representative completed cases selected by instructors.

As the pedagogical role of design cases continues to evolve, the assumptions underlying traditional case teaching become increasingly difficult to sustain. When students are capable of generating, modifying, and comparing numerous design solutions within a short period, learning is no longer centred on understanding a limited number of exemplary cases but on critically evaluating, iteratively improving, and reflecting upon multiple design possibilities. Consequently, a product-oriented case teaching approach that emphasises the analysis of final design outcomes can no longer adequately support AI-assisted design learning, which is characterised by continuous interaction, iterative design development, and collaborative knowledge construction between learners and AI. These changes indicate that the limitations of traditional case teaching do not simply arise from the introduction of a new technological tool; rather, they stem from a fundamental mismatch between an evolving design learning paradigm and pedagogical approaches developed for pre-AI learning environments.

Emerging challenges for AI-assisted case teaching

The transformation of design learning brought about by generative AI not only exposes the limitations of traditional case teaching but also raises new expectations for its future development. As students increasingly engage with AI throughout the design process, case teaching must evolve from a knowledge transmission approach towards a learning-oriented pedagogical framework that better supports human–AI collaborative learning. Rather than simply incorporating AI-generated content into existing teaching activities, educators need to reconsider how design cases are selected, organised, analysed, and evaluated in order to reflect the characteristics of AI-assisted design practice.

First, case teaching should shift from a product-oriented approach to a process-oriented learning approach. Traditional case teaching primarily focuses on analysing completed design works, emphasising visual outcomes, functional performance, and aesthetic quality. While these aspects remain important, they reveal only the final stage of design decision-making. In AI-assisted design learning, students continuously interact with generative AI through prompting, evaluation, revision, and optimisation before arriving at a final solution. Consequently, effective case teaching should encompass the entire design process rather than merely presenting finished products. Design cases should therefore document how ideas are generated, how design decisions evolve, and how iterative improvements are achieved through human–AI collaboration.

Second, learners should become active constructors rather than passive recipients of design cases. Under traditional case teaching, students mainly acquire knowledge by analysing instructor-selected examples. In AI-supported learning environments, however, students are capable of generating their own design cases through interactions with AI systems. This transformation changes students from observers of existing knowledge into producers of new learning experiences. Accordingly, case teaching should encourage students to generate, compare, evaluate, and refine AI-assisted design solutions while developing critical thinking and independent design judgement throughout the learning process.

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Finally, the evaluation of case learning should extend beyond final design outcomes to include the entire learning process. Conventional assessment often concentrates on the quality of completed design works, providing limited insight into how students develop ideas, make design decisions, or improve their work over time. AI-assisted learning, by contrast, produces rich evidence of students' cognitive processes, including prompt design, iterative modification, reflective evaluation, and collaborative decision-making with AI. These learning processes constitute important indicators of design competence and therefore deserve systematic attention within case teaching. Process-oriented assessment can better capture students' problem-solving ability, creative reasoning, and reflective practice than evaluation based solely on final products.

Taken together, these emerging challenges indicate that the reconstruction of case teaching should not be understood as a simple integration of AI technologies into existing instructional practices. Instead, it requires a comprehensive rethinking of how design cases are generated, interpreted, experienced, and evaluated throughout AI-assisted learning. Addressing these challenges calls for a systematic pedagogical framework capable of supporting process-oriented, collaborative, and reflective learning in packaging design education. The following section therefore proposes the Generation–Analysis–Iteration–Reflection (GAIR) case teaching model as a conceptual framework for reconstructing case teaching under the context of generative AI.

The Gair Pedagogical Model

Overview of the GAIR Pedagogical Model

Based on the pedagogical challenges identified in the previous section, this study proposes the Generation–Analysis–Iteration–Reflection (GAIR) case teaching model as a conceptual framework for reconstructing case teaching in packaging design courses under the context of generative artificial intelligence. Rather than treating case teaching as a linear instructional process centred on analysing completed design works, the proposed model reconceptualises design cases as dynamic learning processes that evolve through continuous human–AI collaboration. In this framework, students actively construct design knowledge by generating, analysing, refining, and reflecting upon multiple design alternatives, while teachers facilitate learning by designing authentic tasks, scaffolding critical inquiry, and supporting reflective practice. Consequently, case teaching shifts from the transmission of predefined knowledge towards the facilitation of process-oriented learning, enabling students to develop higher-order design competencies required in AI-assisted design environments.The GAIR model consists of four interconnected pedagogical stages: Generation, Analysis, Iteration, and Reflection. Each stage addresses a specific challenge identified in the previous section while collectively forming a recursive learning cycle that supports creative exploration, critical reasoning, continuous optimisation, and reflective judgement. Unlike traditional case teaching, in which design cases are primarily regarded as completed instructional examples, the GAIR model positions design cases as evolving learning resources that accompany the entire design process. Through repeated interactions between learners and generative AI, students continuously construct, evaluate, and reconstruct design knowledge, thereby transforming case teaching from a product-oriented instructional approach into a process-oriented pedagogical model.

To provide an overview of the proposed framework, Table 1 summarises the pedagogical purpose, teacher's role, student activity, and core competency associated with each stage of the GAIR model.

Table 1. Pedagogical Framework of the GAIR Case Teaching Model

Stage	Pedagogical Purpose	Teacher's Role	Student Activity	Core Competency Developed
Generation	Expand design possibilities through AI-assisted exploration	Design authentic learning tasks and guide prompt formulation	Generate, compare and select multiple AI-assisted design alternatives	Creative Exploration

Analysis	Develop design reasoning through critical interpretation	Facilitate discussion and scaffold analytical thinking	Analyse prompts, design decisions and AI-generated solutions	Design Reasoning
Iteration	Improve design quality through continuous refinement	Provide formative feedback and organise iterative critique	Revise prompts, optimise solutions and compare iterations	Design Optimisation
Reflectio n	Internalise design knowledge through reflective learning	Guide reflective dialogue and process-oriented assessment	Reflect on design decisions, AI collaboration and learning strategies	Design Judgement

As summarised in Table 1, the four stages of the GAIR model perform distinct pedagogical functions while remaining closely interconnected. Rather than representing isolated teaching activities, each stage contributes to students' progressive development of design competence. Generation encourages learners to explore multiple design possibilities; Analysis cultivates evidence-based design reasoning; Iteration promotes continuous design optimisation through human–AI collaboration; and Reflection facilitates the internalisation of knowledge and professional judgement. Collectively, these stages establish a coherent pedagogical framework for process-oriented case teaching in packaging design education.

The dynamic relationship among the four stages is illustrated in Figure 1.

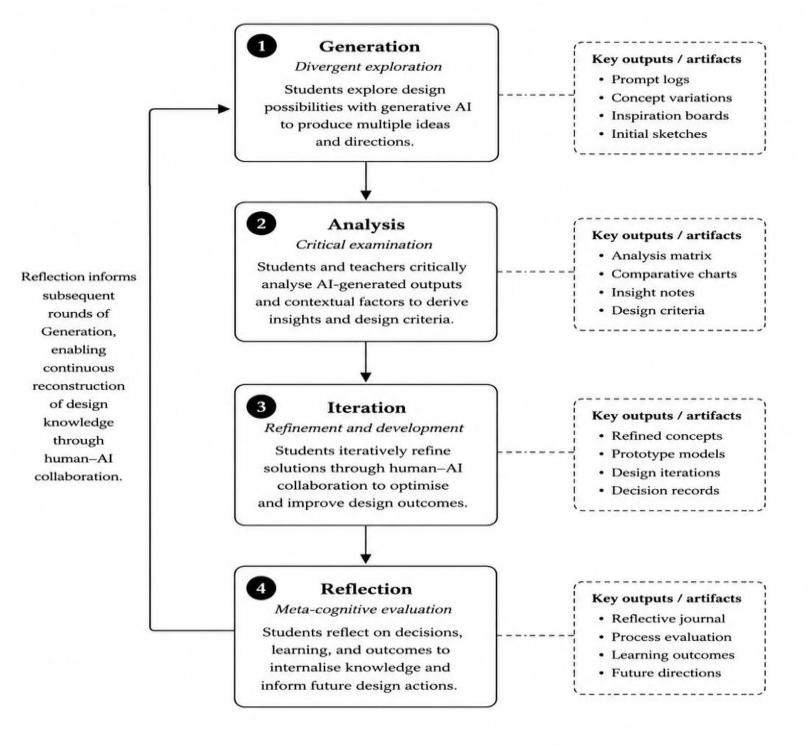

Figure 1. Recursive learning cycle of the GAIR pedagogical model.

Figure 1 illustrates that the GAIR model is designed as a recursive learning cycle rather than a linear instructional sequence. Reflection at the end of one learning cycle informs subsequent rounds of Generation, allowing students to continuously reconstruct design knowledge through repeated interactions with generative AI. In this way, design learning becomes an ongoing process of exploration, evaluation, optimisation, and reflection, instead of a one-time analysis of completed design products. This cyclical mechanism distinguishes the proposed model from traditional case teaching and provides the pedagogical foundation for supporting AI-assisted design learning in packaging design education. Building upon this framework, the following sections explain each stage of the GAIR model in detail.

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Generation

Generation represents the starting point of the GAIR model, where design learning begins with the exploration rather than the explanation of design possibilities. In traditional case teaching, students typically learn from instructor-selected examples before applying acquired knowledge to subsequent design tasks. Such an approach assumes that representative cases already exist and that learning primarily occurs through analysing completed design outcomes. However, the emergence of generative artificial intelligence fundamentally changes this assumption. Instead of relying exclusively on existing cases, students are now able to generate multiple design alternatives in response to authentic design briefs through continuous interaction with AI. Consequently, the starting point of case teaching shifts from the interpretation of predefined cases to the construction of new design possibilities. This transformation is consistent with the principles of designerly thinking, which regard design as an exploratory process centred on generating and developing possible solutions rather than identifying predetermined answers (Cross, 2006). Likewise, Lawson (2006) argues that design thinking develops through the continual generation and evaluation of alternative solutions. Therefore, the Generation stage establishes the pedagogical foundation of the GAIR model by positioning case generation itself as an integral component of learning rather than merely a preparatory activity.

Within the Generation stage, the teacher assumes the role of a learning facilitator instead of a provider of exemplary cases. Rather than presenting finished packaging designs for students to imitate, teachers design authentic project briefs that encourage open-ended exploration and guide students in constructing effective prompts aligned with specific design objectives. Students actively interact with generative AI to produce, compare, and evaluate multiple design alternatives while continuously adjusting prompts according to functional requirements, aesthetic preferences, target users, and cultural contexts. For example, in a packaging design course, learners may begin with the same product brief but obtain substantially different packaging concepts by modifying design constraints related to branding, sustainability, materials, colour schemes, or consumer positioning. These AI-assisted design alternatives subsequently become authentic learning cases that provide the basis for later analysis and discussion. In this way, case resources are no longer predetermined teaching materials prepared solely by instructors but are collaboratively generated by students through human–AI collaboration.

The educational value of the Generation stage lies not in accelerating visual production but in expanding students' capability for creative exploration. By encouraging learners to construct and compare multiple design possibilities before evaluating them, Generation shifts the emphasis of case teaching from reproducing existing knowledge to discovering new design opportunities. More importantly, it transforms design cases from static instructional examples into evolving learning resources that record students' design thinking throughout the creative process. This process-oriented conception of design cases provides the necessary foundation for the subsequent Analysis stage, in which students critically examine the rationale, strengths, and limitations of the generated design alternatives. Consequently, Generation serves as the pedagogical entry point of the GAIR model, cultivating students' competence in creative exploration while preparing them for deeper analytical learning in AI-assisted packaging design education.

Analysis

Following the Generation stage, the Analysis stage shifts students' attention from producing design alternatives to understanding the reasoning that underpins those alternatives. Rather than evaluating packaging concepts solely on the basis of visual quality, students are encouraged to examine how design decisions emerge through interactions between design briefs, prompt formulation, AI-generated responses, and contextual constraints. Accordingly, analysis becomes a process of interpreting design reasoning instead of merely judging design outcomes. This perspective reflects Schön's (1983) concept of reflective practice, which emphasises examining professional reasoning in action, and is consistent with Shulman's (1986) view that meaningful learning develops through the interpretation and justification of disciplinary knowledge rather than the reproduction of existing solutions. Within case-based learning, authentic cases therefore serve not only as examples of successful practice but also as opportunities for learners to understand how professional judgements are formed (Merseth, 1991).

In the GAIR model, teachers facilitate analytical inquiry rather than provide authoritative interpretations. Instead of explaining why a particular packaging design is successful, teachers guide students to compare multiple AI-generated packaging cases and examine the reasoning behind different design decisions. Students analyse how prompt formulation influences visual communication, how structural choices respond to functional requirements, whether branding and packaging graphics effectively communicate product identity, and how material selection or sustainability considerations affect design feasibility. Through collaborative discussion, peer critique, and evidence-based comparison, learners are encouraged to justify design decisions with reference to packaging principles rather than personal preference. Consequently, AI-generated packaging cases become analytical resources that reveal the relationship between design intention, decision-making, and design outcome.

The educational value of the Analysis stage lies in cultivating design reasoning. Rather than accepting AI-generated solutions as inherently appropriate, students learn to critically evaluate alternative design strategies, recognise the strengths and limitations of AI-assisted outputs, and determine whether particular design decisions satisfy aesthetic, functional, and commercial requirements. Analysis therefore shifts the focus of case teaching from describing completed packaging designs to explaining why certain solutions are more appropriate within specific design contexts. More importantly, the analytical insights developed during this stage provide the evidence required for subsequent refinement. By identifying limitations in existing design solutions, students are able to revise prompts, adjust design strategies, and optimise packaging concepts through further interaction with generative AI. Analysis therefore functions as the cognitive bridge between creative exploration and iterative improvement, preparing learners for the Iteration stage of the GAIR model.

Iteration

Building upon the analytical insights developed in the previous stage, Iteration focuses on improving design quality through continuous revision rather than evaluating completed solutions. Instead of treating analysis as the end of learning, the GAIR model positions it as the starting point for further optimisation. Students are expected to transform analytical findings into subsequent design actions by refining prompts, modifying design strategies, and testing alternative solutions through repeated interaction with generative AI. In this way, learning becomes an ongoing cycle of experimentation, evaluation, and improvement instead of a one-time process of case analysis. This iterative perspective is consistent with experiential learning theory, which emphasises learning through repeated cycles of experience, reflection, conceptualisation, and experimentation (Kolb, 1984). Similarly, design research recognises that effective design solutions emerge through continuous refinement rather than a single creative attempt (Oxman, 2008).

Within the Iteration stage, teachers support learning by providing formative feedback and organising structured critique instead of simply evaluating final design products. Students are encouraged to revise AI prompts, compare successive versions of packaging concepts, and justify each modification according to explicit design objectives. For example, learners may refine packaging graphics to strengthen brand communication, adjust structural layouts to improve usability, or modify material choices to enhance sustainability and production feasibility. Each revision is supported by evidence gathered during the Analysis stage rather than by subjective preference alone. Throughout this process, both successful and unsuccessful iterations are documented as part of the evolving design case, allowing students to trace how design reasoning develops across multiple rounds of human–AI collaboration.

The educational value of Iteration lies in developing students’ capacity for design optimisation. Rather than viewing revision as a corrective activity, the GAIR model treats iterative refinement as the principal mechanism through which design competence develops. Repeated comparison, modification, and evaluation enable learners to translate analytical understanding into practical improvement while strengthening their ability to make informed design decisions in collaboration with AI. More importantly, documenting successive iterations transforms design cases into records of learning rather than collections of final products. These evolving cases not only demonstrate how packaging solutions improve over time but also preserve the reasoning behind each design decision. Consequently, Iteration establishes the process-oriented foundation for reflective learning and prepares students for the final Reflection stage of the GAIR model.

Reflection

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Reflection constitutes the concluding stage of the GAIR model, in which students consolidate design knowledge by critically evaluating both their design outcomes and the reasoning that produced them. While the Iteration stage focuses on improving packaging solutions through successive refinement, Reflection shifts attention towards understanding how design decisions evolved throughout the entire human–AI collaborative process. Rather than treating reflection as a summary conducted after learning has finished, the GAIR model regards it as an integral learning activity through which students internalise design experience, develop professional judgement, and prepare for future design practice. This perspective is consistent with Schön's (1983) concept of reflective practice, which emphasises learning through critical examination of professional actions, and with Moon's (1999) view that reflection transforms experience into transferable knowledge. In AI-assisted learning environments, reflective engagement is increasingly important because students must continuously evaluate not only the quality of AI-generated outputs but also the appropriateness of AI-supported decision-making (Kasneci et al., 2023; UNESCO, 2023).

Within the Reflection stage, teachers facilitate structured reflection by encouraging students to review the complete trajectory of their packaging design projects rather than focusing exclusively on final products. Students examine how initial design intentions evolved across successive iterations, whether modifications effectively addressed design requirements, how interactions with generative AI influenced creative thinking, and which design strategies proved most appropriate under different packaging contexts. Reflection may be supported through design portfolios, learning journals, peer discussion, and process documentation, enabling learners to articulate not only what decisions were made but also why those decisions were justified. Through this process, students gradually develop the ability to critically evaluate both their own design reasoning and the role of AI within professional design practice. Consequently, the entire sequence of generation, analysis, iteration, and reflection becomes a reusable design case that informs subsequent learning.

The educational value of Reflection lies in cultivating design judgement. Rather than measuring learning solely through the quality of completed packaging designs, the GAIR model emphasises students' ability to justify design decisions, critically assess AI-assisted solutions, and transfer acquired experience to new design situations. Reflection therefore transforms design cases from temporary classroom activities into enduring learning resources that support continuous professional development. More importantly, the insights generated through reflection initiate a new cycle of design exploration, allowing students to approach subsequent projects with more sophisticated design reasoning and greater awareness of both the opportunities and limitations of generative AI. In this way, Reflection completes the recursive learning cycle of the GAIR model and reinforces the transition from product-oriented case teaching to a process-oriented pedagogical model for packaging design education.

DISCUSSION

Theoretical Implications

The proposed GAIR pedagogical model contributes to the growing body of research on AI-assisted design education by reconceptualising case teaching from a pedagogical rather than a technological perspective. Existing studies have primarily examined the application of generative AI in creative ideation, design production, and curriculum innovation (Kasneci et al., 2023; Dwivedi et al., 2023; Meron and Tekmen Araci, 2023). Although these studies have demonstrated the considerable potential of AI to support design learning, they have paid comparatively less attention to how pedagogical approaches themselves should be redesigned to accommodate AI-assisted learning. The present study argues that the educational significance of generative AI lies not simply in expanding students' creative capabilities but in transforming the way design learning is organised. Accordingly, the GAIR model shifts the emphasis of case teaching from analysing completed design products to facilitating the continuous construction of design knowledge through human–AI collaboration.

A second theoretical contribution lies in redefining the educational role of design cases. Within traditional case teaching, design cases are generally regarded as stable instructional resources selected and interpreted by teachers before being presented to students for analysis (Merseth, 1991). The GAIR model challenges this assumption by positioning design cases as evolving pedagogical resources that emerge throughout the processes of generation, analysis, iteration, and reflection. Consequently, design cases no longer function solely as

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examples for knowledge transmission; instead, they document students' design reasoning, iterative decision-making, and collaborative interactions with generative AI. This process-oriented perspective extends existing understandings of case-based learning by recognising that valuable learning resources can be continuously created by learners themselves rather than exclusively provided by instructors.

Finally, this study offers a pedagogical interpretation of human–AI collaboration within packaging design education. Previous research has frequently discussed human–AI collaboration in terms of creative performance, design efficiency, or technological capability (Kasneci et al., 2023; Meron and Tekmen Araci, 2023). By contrast, the GAIR model conceptualises human–AI collaboration as a learning process through which students progressively develop creative exploration, design reasoning, design optimisation, and design judgement. These four competencies together constitute an integrated framework for cultivating design competence in packaging design education. From this perspective, the contribution of the GAIR model extends beyond AI adoption itself by demonstrating how pedagogical innovation can enable students to learn with AI rather than merely learn to use AI.

Practical Implications

Beyond its theoretical contributions, the GAIR pedagogical model provides practical guidance for redesigning teaching practices in packaging design courses within AI-assisted learning environments. Rather than introducing generative AI as an additional digital tool, the proposed model suggests that curriculum redesign should be centred on the reconstruction of learning processes. This perspective aligns with previous research arguing that the educational value of AI depends primarily on pedagogical innovation rather than technological adoption alone (Zawacki-Richter et al., 2019; Kasneci et al., 2023). Within packaging design education, this implies that learning activities should be organised around authentic packaging design briefs that encourage students to generate, analyse, refine, and reflect upon multiple design solutions through continuous human–AI collaboration. In this way, AI becomes a medium for supporting design inquiry rather than simply accelerating design production.

The GAIR model also highlights the changing professional role of teachers in AI-supported packaging design studios. Instead of functioning primarily as providers of exemplary design cases, teachers are expected to facilitate inquiry by designing authentic packaging projects, scaffolding students' prompt design, organising collaborative critique, and guiding evidence-based decision-making throughout the design process. More importantly, teachers are responsible for helping students critically evaluate AI-generated packaging concepts with reference to branding, structural performance, sustainability, manufacturability, and user experience rather than accepting AI outputs uncritically. This evolving role is consistent with the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasises the integration of disciplinary expertise, pedagogy, and technology in technology-enhanced learning (Mishra & Koehler, 2006). Likewise, UNESCO (2023) highlights the importance of preparing educators to guide learners in using generative AI responsibly, critically, and ethically. Within the GAIR model, effective teaching therefore depends not only on technological proficiency but also on teachers' ability to orchestrate meaningful learning through human–AI collaboration.

The proposed model further suggests the need to redesign assessment practices in packaging design education. Conventional assessment often focuses on evaluating the quality of final packaging prototypes while providing limited evidence of how students develop design ideas or justify design decisions. By contrast, the GAIR model advocates process-oriented formative assessment that documents students' learning throughout the four pedagogical stages. Assessment evidence may include prompt design records, design iteration portfolios, reflective journals, peer critiques, and design decision logs, all of which capture the evolution of students' design reasoning rather than only their final products. Such an approach is consistent with formative assessment theory, which emphasises continuous feedback as a mechanism for improving learning rather than simply measuring achievement (Black & Wiliam, 1998; Nicol & Macfarlane-Dick, 2006). By recognising students' progress across the entire design process, process-oriented assessment enables educators to evaluate the development of design competence in a more comprehensive and authentic manner.

Limitations

Despite its theoretical and pedagogical contributions, this study has several limitations that should be acknowledged. First, the GAIR pedagogical model is proposed as a conceptual framework rather than an empirically validated instructional model. The framework is developed through the integration of literature on generative AI, packaging design education, and case-based learning, but it has not yet been systematically implemented or evaluated in authentic educational settings. Consequently, although the model provides a theoretically grounded approach to reconstructing case teaching, its effectiveness in enhancing students' design competence, learning engagement, and educational outcomes requires further empirical verification.

Second, the proposed model is developed specifically for packaging design education, where students are required to integrate visual communication, structural design, branding, sustainability, and market considerations within authentic design projects. Although the underlying pedagogical principles—including human–AI collaboration, iterative learning, and reflective practice—may be applicable to other studio-based design disciplines, their implementation is likely to require contextual adaptation. Future applications should therefore take into account the distinctive learning objectives, studio cultures, and assessment practices of individual design fields rather than assuming direct transferability.

Third, the implementation of the GAIR model may be influenced by differences in AI literacy among both students and teachers. Learners with varying levels of experience in prompt design, critical evaluation, and AI-assisted problem-solving may engage differently with the four pedagogical stages, while teachers' familiarity with generative AI may also affect the quality of learning facilitation. As AI literacy continues to emerge as an important competency in higher education, future studies should examine how differences in AI-related knowledge and experience influence the effectiveness of process-oriented case teaching. This observation is consistent with recent discussions highlighting AI literacy as an emerging educational competency required for effective and responsible AI use in higher education (Ng et al., 2021).

Finally, the rapid evolution of generative AI technologies presents an ongoing challenge for pedagogical model development. Emerging capabilities such as multimodal generation, intelligent agents, and increasingly autonomous design support are likely to reshape both design practice and educational activities. Consequently, the pedagogical functions associated with each stage of the GAIR model may require continuous refinement as technological capabilities and educational needs evolve. The model proposed in this study should therefore be regarded as an adaptive pedagogical framework that is expected to develop alongside future advances in AI-assisted packaging design education rather than as a fixed instructional procedure.

Future Research

The GAIR pedagogical model provides a conceptual foundation for future research on AI-assisted case teaching while opening several directions for further investigation. The first priority is to examine the pedagogical effectiveness of the proposed model through empirical implementation in authentic educational settings. Although the present study establishes a theoretically grounded framework by integrating research on generative AI, packaging design education, and case-based learning, its educational value ultimately depends on how it supports students' learning in practice. Design-based research (DBR) provides a particularly appropriate methodological approach because it enables researchers to iteratively design, implement, evaluate, and refine pedagogical interventions within real classroom contexts (Design-Based Research Collective, 2003; Reeves, 2006). Future studies employing DBR, together with mixed-methods research, could provide robust evidence regarding how the four stages of the GAIR model contribute to the development of students' creative exploration, design reasoning, design optimisation, and design judgement.

A second direction concerns the broader applicability of the GAIR model across different educational contexts. While this study focuses specifically on packaging design education, many of the pedagogical principles underpinning the model—including iterative learning, human–AI collaboration, and reflective practice—may also be relevant to other studio-based disciplines such as industrial design, visual communication design, and digital media design. Comparative research conducted across different design programs, educational levels, and cultural settings would help identify which pedagogical components of the GAIR model are transferable and which require contextual adaptation. Such studies would contribute to a more comprehensive theoretical understanding of AI-assisted case teaching within design education.

Finally, future research should continue to refine pedagogical models alongside the rapid evolution of generative AI technologies. Emerging developments in multimodal foundation models, intelligent agents, and increasingly autonomous design support are expected to reshape the ways in which students generate ideas, collaborate with AI, and develop professional design competence (Dwivedi et al., 2023; Kasneci et al., 2023). Rather than treating pedagogical frameworks as fixed instructional procedures, future studies should investigate how advances in AI capabilities influence case generation, teacher facilitation, assessment practices, and students' learning experiences. From this perspective, the GAIR model should be understood as an evolving pedagogical framework that is expected to develop continuously in response to future innovations in AI-assisted packaging design education.

CONCLUSION

The rapid advancement of generative AI is transforming not only how design solutions are produced but also how design knowledge is constructed, shared, and learned. While previous research has primarily explored the technological applications of generative AI in creative practice and design education, comparatively less attention has been devoted to how pedagogical approaches should be reconfigured to support AI-assisted learning. Responding to this challenge, the present study has argued that the integration of generative AI into packaging design education requires more than the adoption of new technologies; it requires the reconstruction of case teaching to better support students' continuous learning through human–AI collaboration.

To address this need, this study proposed the Generation–Analysis–Iteration–Reflection (GAIR) pedagogical model as a process-oriented approach to reconstructing case teaching in packaging design courses. Rather than treating design cases as static instructional examples selected by teachers, the proposed model conceptualises them as evolving pedagogical resources that accompany students throughout the entire design process. Through the four interconnected stages of Generation, Analysis, Iteration, and Reflection, learners progressively develop creative exploration, design reasoning, design optimisation, and design judgement, thereby transforming case teaching from a product-oriented instructional approach into a learning process centred on continuous knowledge development.

The study contributes to the literature in three respects. Theoretically, it extends existing research on case-based learning by redefining the educational role of design cases within AI-assisted learning environments. Pedagogically, it demonstrates how human–AI collaboration can be organised through a coherent teaching model that supports the continuous construction of design knowledge rather than the simple application of AI technologies. Practically, the proposed model offers guidance for curriculum design, teacher facilitation, and formative assessment in packaging design education, providing educators with a structured framework for integrating generative AI into studio-based learning.

Although the GAIR model remains a conceptual framework requiring empirical validation, it provides a foundation for future pedagogical innovation in AI-assisted design education. As generative AI continues to evolve, the educational challenge is no longer simply how to use AI effectively, but how to organise meaningful learning experiences in which human creativity, critical judgement, and AI capabilities complement one another. Ultimately, the educational value of generative AI lies not in replacing human designers or automating creative work, but in enabling design cases to evolve from static instructional examples into dynamic pedagogical resources that continuously support the development of students' design competence.

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