

An AI-Driven Framework for Teaching Industrial Design Students Using a Generate-and-Evaluate Approach Within the Double Diamond Model

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Abstract

As AI technologies increasingly influence the design industry, there is a growing need to equip design students with skills in generative AI (GenAI) and machine learning (ML) to stay competitive. This paper presents an AI-driven framework for teaching industrial design students using a generate-and-evaluate approach within the double diamond model. This framework integrates GenAI and ML to enhance creativity, analytical skills, and brand-focused thinking. Students first use Stable Diffusion, a GenAI model, to explore diverse car design concepts inspired by Porsche's aesthetics, engaging in a divergent phase that expands creative possibilities. To manage the large volume of designs, students then apply classification models with Weka, an ML tools, in the convergent phase to filter and select options aligned with Porsche's brand identity. This evaluation step teaches students to critically assess the relevance and consistency of AI-generated results, reinforcing the double diamond model's balance between exploration and refinement. The framework offers key insights into design education. First, it bridges AI—including generative and ML classification—with traditional design processes, making AI more accessible to students. Second, the structured generate-and-evaluate approach aligns with students' natural design inclinations, fostering higher engagement and acceptance of AI as a valuable tool. Finally, the framework provides a scalable model for broader design education, adaptable across various design disciplines, supporting a technology-rich curriculum. By blending innovative technology with established design methods, this study highlights an effective approach to preparing students for industry demands through experiential learning with AI tools.

Keywords: generative artificial intelligence, machine learning, double diamond model, AI-driven design process, industrial design education

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Introduction

Artificial intelligence (AI) has emerged as a transformative force in industrial design, influencing concept generation, evaluation, and product development. However, many industrial design curricula lack a structured framework for integrating AI into the traditional design process. The Double Diamond Model, widely used in design thinking, provides a structured approach, but its application of AI remains fragmented. Existing AI-driven studies focus on the later stages of design, Develop and Deliver, while AI's role in Discover and Define is underutilized. Addressing this gap is crucial for enhancing industrial design education.

Furthermore, while designers are beginning to adopt AI tools, many students and educators struggle to integrate these technologies effectively. The lack of a systematic, pedagogically sound approach leads to inconsistent learning outcomes. This paper aims to resolve this by presenting a cohesive framework that not only enhances creativity but also cultivates critical evaluation and decision-making skills, crucial for future industrial designers.

Studies on AI-assisted design often emphasize the role of generative artificial intelligence (GenAI) in concept ideation while neglecting systematic evaluation methods. As a result, students and educators may struggle to assess the quality and relevance of AI-generated outputs, leading to inconsistent design outcomes. Additionally, existing adaptations of the Double Diamond Model incorporate AI unevenly, with most applications focusing on later-stage refinement rather than early-stage research and problem framing. Consequently, the lack of structured AI training in design programs exacerbates student uncertainty, leaving them unsure of how to use AI effectively throughout the entire design workflow.

The Generate-and-Evaluate Approach directly addresses this gap by providing a structured methodology that balances AI-driven creativity with systematic evaluation. By integrating creative generation and analytical refinement into an iterative cycle, this approach ensures that AI-generated solutions are not only diverse but also strategically validated before selection. In AI-driven design processes, GenAI rapidly produces multiple alternatives, expanding the design space. However, without an evaluation mechanism, this flood of options can lead to decision paralysis and inconsistency. To counter this, machine learning (ML) models and rule-based evaluation techniques help assess the quality, relevance, and feasibility of AI-generated concepts. By embedding both exploration and validation into the design process, the Generate-and-Evaluate Approach enhances AI's role from merely producing ideas to actively shaping high-quality, industry-relevant design outcomes.

The paper proposes a new AI-enhanced framework that addresses the gap by integrating the Generate-and-Evaluate Approach into the Double Diamond Model for industrial design students by synthesizing insights from prior research on AI applications within the Double Diamond Model to develop a structured Generate-and-Evaluate AI-enhanced framework for design education.

AI Integration in Design: Double Diamond Model and Generate-and-Evaluate Approach

Double Diamond Design Process

The Double Diamond Model, developed by the UK Design Council, is a widely adopted framework for structured design processes, consisting of four phases: Discover, Define, Develop, and Deliver. It facilitates a balance between divergent exploration and convergent refinement, ensuring that design solutions are rooted in deep user insights and iterative prototyping. However, traditional applications of the model have largely relied on human-centered methodologies, with limited integration of AI.

Recent research has highlighted the uneven distribution of adoption of AI during the double diamond phase. Although AI is increasingly being used at the development and delivery stages for concept improvement, prototype and production (Lee et al., 2025), its role in exploration and definition is still not widely known. This limitation prevented AI from fully supporting early research, problem definition, and creative direction, where it could improve trend analysis, synthesis of user insight, and synthesis of ideas.

To address this limitation, several adaptations of the Double Diamond Model have incorporated AI or interdisciplinary strategies to varying degrees. Viviani et al. (2024) developed the Interdisciplinary Double Diamond, integrating design research and engineering methodologies to drive urban transport product innovation, though its primary focus is not on AI applications. While these adaptations contribute to refining design thinking methodologies, few fully integrate both generative and evaluative AI tools across all four phases of the Double Diamond Model.

Generate-and-Evaluate Design Approach

To address the gaps in AI integration, researchers have explored the Generate-and-Evaluate Approach, which combines AI-driven ideation with structured evaluation mechanisms. This approach is particularly relevant in industrial design education, where students benefit from both expansive creativity and critical assessment skills to refine their work. In the field of industrial design, GenAI tools such as ChatGPT, DALL·E, Midjourney, and Vizcom can effectively generate multiple design solutions in a short time. Tang et al. (2024) identify the distinction between Pre-AI (divergent) and Post-AI (convergent) design phases, and how AI tools assist in ideation, visualization, and iterative refinement. These tools expand the divergent exploration phase by allowing designers to quickly visualize multiple aesthetic, functional, and material variations. However, without systematic evaluation methods, AI-generated outputs risk being unfiltered, misaligned with brand identity, or impractical for manufacturing.

In contrast, ML classification, such as Weka and Orange, has potential to accurately classify AI-generated concepts based on predefined criteria to facilitate the convergent selection process. The first author has co-authored several related papers that demonstrate how GenAI can be systematically integrated with ML classification to refine design outcomes. For example, Wang and Chen (2025) employ Stable Diffusion to generate BMW electric vehicle designs, allowing AI to explore multiple styling variations within the brand's identity. To assess these designs, they use Weka classification with PHOG feature extraction, ensuring that AI-generated outputs maintain a balance between brand typicality and novelty. Another

example is that Wang and Lu (2025) apply the Generate-and-Evaluate Approach to classify AI-generated SUV designs into four semantic categories: aggressive, sporty, clean, and off-road. AI tools are first used to create diverse SUV designs, which are then evaluated using Random Forest models in Weka to determine their alignment with predefined styling semantics. These studies highlight how GenAI can expand creative possibilities, while ML provides a quantifiable evaluation method to guide designers in selecting the most relevant concepts.

Building on this foundation, the integration of AI-generated exploration and ML-driven assessment ensures that students not only engage in freethinking but also develop structured decision-making capabilities when evaluating AI output. Despite these benefits, the implementation of the Generate-and-Evaluate Approach within the Double Diamond Model remains underdeveloped. Recognizing this gap, several studies emphasize the need for structured AI integration in design workflows. Lai et al. (2023) explored how GenAI impacts design workflows, highlighting the necessity of structured AI integration to prevent AI from being used in an ad-hoc manner. Similarly, Lyu et al. (2023) examined the speculative potential of AI-driven co-design processes, reinforcing the importance of a systematic framework that embeds AI tools across all design phases.

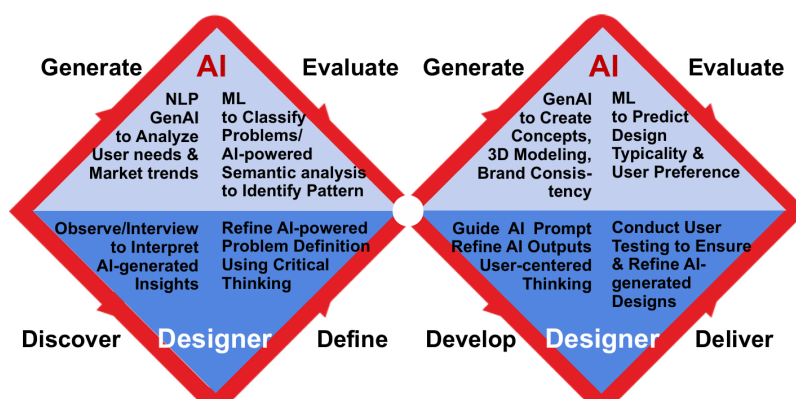
For AI-driven industrial design education, we argue that a well-structured framework is needed that:

- Integrates AI tools across all Double Diamond phases, from research & ideation (Discover, Define) to refinement & implementation (Develop, Deliver), and
- Combines GenAI (Stable Diffusion, Midjourney) with evaluative AI (ML classifiers, feature extraction tools like Weka) for structured decision-making.

Proposed AI-Driven Design Framework

This study proposes an AI-driven framework for teaching industrial design students using the Generate-and-Evaluate Approach with the Double Diamond Model, as shown in Figure 1. In the framework, the Discover and Develop phases align with Generate, where human designers leverage GenAI to explore possibilities. The Define and Deliver phases correspond to Evaluate, where Machine Learning (ML) techniques assist designers in refining, filtering, and validating design solutions. This framework establishes a co-creative partnership between AI and design students, enhancing both divergent ideation and convergent decision-making.

Figure 1
Framework for Teaching AI-Driven Design



As shown in Table 1, the framework integrates GenAI and ML into the Double Diamond Model, thereby structuring AI-assisted ideas and assessments in design education. Following a Generate-and-Evaluate approach, GenAI promotes creative exploration in the phases of discovery and development, while ML enables structured refinement in the phases of definition and delivery. By detailing the use of AI and ML tools at each stage, the framework explains how technology improves the design process and preserves the essential role of human designers in the refinement, validation and contextualization of AI-generated outputs.

As AI evolves, the framework is adaptable, enabling the design process to be reconfigured to reflect emerging technological advances. As part of the evolving Double Diamond model, it shows how AI contributes to problem discovery, designing challenges, exploring solutions, and evaluating concepts, and strengthens the balance between AI-driven efficiency and human creativity in design education.

To effectively implement this framework, the teaching guidelines emphasize the integration of AI at all stages rather than limiting its use to prototypes. Students are encouraged to use AI in problem construction and refinement to ensure a holistic design process based on AI. Furthermore, instructors should guide students to critically assess AI outputs in order to maintain a balance between creativity generated by AI and human judgement. Finally, AI feedback loops should be incorporated through iterative development and evaluation cycles, so that students can continuously refine ideas based on structured feedback and evaluation.

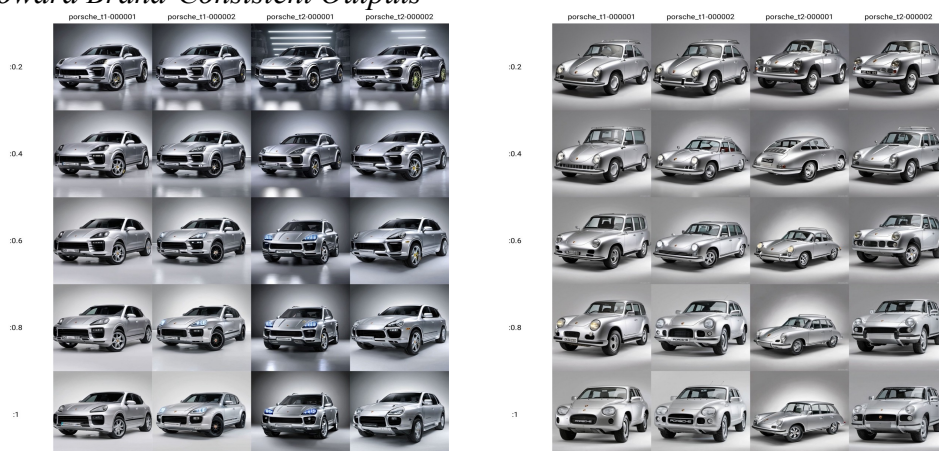
To illustrate how students engage with the Generate phase of the framework, Figure 2 presents examples of AI-generated car designs produced using Stable Diffusion. In this case, a student applied a LoRA-trained model fine-tuned on Porsche visual language to generate SUV and wagon variants. These images exemplify how Generative AI can support exploration of brand-specific design directions, enabling students to rapidly visualize a wide range of stylistic options while maintaining brand identity.

Table 1
Integration of AI-Driven Tools and Designer's Role

AI-Driven Tools	Designer's Role	Integration
Discover/Generate Insight		
ChatGPT (GPT-4 Turbo), BERT-based NLP models	Formulate design research queries, refine AI-generated market insights, and synthesize trend analyses.	Help students understand the problem context by synthesizing insights from diverse sources.
LLM-based topic modeling (LDA, GPT-based clustering)	Interpret AI-clustered design problems and evaluate relevance to user needs.	Assist in identifying patterns in user feedback, structuring observations into key themes.
AI-powered sentiment analysis (Hugging Face Models)	Analyze consumer preferences, identifying pain points and aesthetic expectations.	Enable students to explore user emotions and expectations through AI-generated sentiment trends.
Define/Evaluate Problem		
Weka Decision Tree Classifiers (J48, Random Forest)	Refine AI-structured problem definitions and design briefs using rational analysis and creative intuition.	Support students in developing a clear, well-structured problem definition.
Rule-based ML classifiers (PHOG Feature Extraction, Binary Pattern Pyramid Filters)	Assess AI-categorized design priorities, ensuring cultural and brand alignment.	Help students prioritize key challenges from AI-processed research insights.
Semantic classification models (Weka-based image classification, Car Semantics Analysis)	Validate AI-processed insights to guide design strategies.	Ensure that student-defined problem statements are aligned with user needs.
Develop/Generate Design		
Stable Diffusion, Midjourney, DALL-E	Craft detailed prompts, modify design constraints, and select the most promising outputs.	Allow students to generate multiple interpretations of a problem, expanding creative possibilities.
StyleGAN-based customization for brand-consistent outputs AI-driven 3D concept modeling (Vizcom AI)	Adjust AI-generated designs to preserve visual identity and emotional appeal. Convert 2D AI-generated sketches into structurally feasible 3D models.	Support students in aligning AI-generated concepts with established brand guidelines. Enable students to translate AI-generated visuals into functional product ideas.
Deliver/Evaluate Solution		
Weka-based image classification (Random Forest, PHOG Feature Extraction) Semantic classification of car styling using ML	Validate brand consistency and design feasibility. Evaluate how well AI-generated designs align with semantic expectations.	Help students assess whether AI-generated designs align with real-world constraints. Guide students to refine AI-generated ideas based on consumer perception.
Car styling evaluation with image classification	Assess AI-generated concepts for proportion and composition.	Enable students to select the most well-balanced and aesthetically pleasing designs.

Figure 2

AI-Generated Porsche-Style SUV (Left) and Wagon (Right) Created by a Student Using Stable Diffusion With LoRA Model Training, Reflecting the Student's Ability to Guide GenAI Toward Brand-Consistent Outputs

**Conclusion: AI as a Catalyst for Future Design Education**

This framework reimagines the integration of AI-assisted ideation and ML-driven evaluation within the Double Diamond Model, positioning AI as a catalyst for creativity and structured refinement in design education. By embedding Generative AI (GenAI) in the Discover and Develop phases and Machine Learning (ML) in the Define and Deliver phases, it establishes a co-creative partnership between AI and designers that extends beyond efficiency into augmenting human cognition, intuition, and decision-making.

Drawing on insights from Ivcevic and Grandinetti (2024) on AI as a tool for creativity, the framework aligns with the vision of AI augmenting, rather than replacing, human creativity. AI functions not merely as an automation tool but as a collaborative agent that expands ideation while preserving human judgment. Inspired by Weisz et al. (2024) on Generative AI design principles, the framework ensures AI integration adheres to principles of co-creation, generative variability, and responsible augmentation. These principles emphasize that AI should encourage iterative exploration, enhance structured decision-making, and support creative risk-taking without diminishing the designer's agency.

The future of AI-driven design education hinges on how well students learn to orchestrate AI's computational power with their own creative intuition. As highlighted by O'Toole and Horvát (2024), AI should be designed to support human intentionality rather than dictate design outcomes. The framework envisions an evolving synergy where designers remain the architects of meaning, narrative, and emotional resonance, while AI serves as an enabler of new design possibilities. Future research must explore how AI influences creativity at different levels of expertise, ensuring that AI enriches rather than homogenizes creative expression. By fostering a human-centered yet AI-augmented approach, this framework lays the foundation for a new era of design education where creativity, logic, and technology seamlessly converge.

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