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Leveraging AI Tools to Foster Creative Thinking in the Early Product Design Process

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ABSTRACT

Integrating Artificial Intelligence (AI) into creative learning presents exciting opportunities for enhancing students' innovative capacities across diverse educational settings. By providing transformative tools, AI fosters the development of creative thinking through adaptive feedback, ideation tools, and personalised learning pathways tailored to individual cognitive styles. The objective of this study is to identify the design challenges and concerns associated with the use of AI image generator applications during the early stages of product design ideation. Concerns were focused on three design criteria: form, function, and feasibility. In disciplines such as industrial design, AI plays a crucial role in streamlining complex design processes and merging computational creativity with human-led ideation. A qualitative approach, comprising design process observation and interviews, enabled an in-depth exploration of how AI influences creative thinking within a specific educational context. Seven students were observed engaging with AI image generator applications. Their individual insights were analysed in phases using image analysis, supported by thematic analysis, to assess the psychological impact of their designs in real time. Five themes were identified, namely the creativity level of students, idea quantity, user emotion considerations, time efficiency, and originality concerns. In the future, this synergy is expected to foster creative engagement by providing learners with key insights into the emotional and psychological aspects of their work while enhancing their awareness of novelty.

1. INTRODUCTION

In the rapidly evolving field of industrial design, the early ideation phase is pivotal in shaping design outcomes. This stage demands high levels of creativity, requiring students to generate original and contextually sensitive ideas. However, a persistent challenge in design education is the difficulty novice designers face in overcoming creative blocks and initiating ideation beyond conventional frameworks (Cross, 2011; Dorst & Cross, 2001). Although students are trained in iterative thinking and

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conceptualisation techniques, many continue to struggle to produce innovative and emotionally resonant design concepts at this critical juncture.

Recent developments in artificial intelligence (AI), provided as generative models and multimodal learning, offer new avenues for augmenting creativity in education. The application of AI image generators, such as DALL·E, Midjourney, and OpenAI Art, offers students with visual stimuli that can inspire fresh perspectives and encourage divergent thinking. When integrated thoughtfully, these tools serve not merely as output generators but as cognitive partners that scaffold the ideation process (Kim & Maher, 2023).

AI technologies, particularly those employing machine learning and deep learning algorithms, have demonstrated promise in various creative domains, including art and design (McCormack, Gifford, & Hutchings, 2019). By leveraging AI's capacity to generate a wide range of visual stimuli, students may overcome creative blocks and expand their ideation horizons. This study evaluates the effectiveness of AI-generated imagery in stimulating novel ideas and enhancing students' creativity during the initial phases of the design process.

The significance of this study lies in its potential to transform design education through the integration of advanced technological tools that address fundamental challenges in the creative process. Incorporating AI into the design curriculum provides students with a powerful resource for ideation, thereby fostering a more innovative and dynamic learning environment. This research contributes to the expanding discourse on the intersection of technology and creativity in education, with particular emphasis on how AI can augment human creative capacities (Runco, 2004). The skill set is increasingly valuable in a competitive market that demands innovative solutions and the capacity to adapt rapidly to shifting design paradigms (Brown, 2008). Therefore, this study seeks to investigate the use of AI design applications in the early stages of product design education to foster creative thinking and prepare students for how AI-generated images can inspire and support the ideation process.

2. LITERATURE REVIEW

AI is transforming the way creativity is understood and practised. Numerous studies demonstrate that AI can support and enhance human creativity. For instance, Meng et al. (2024) found that AI technologies, such as deep learning and generative algorithms, can generate ideas that inspire human designers. In their research on AI in architecture, they showed that AI-generated designs led to more innovative and diverse solutions, thereby improving the creative process (Meng et al., 2024).

In the fashion industry, Smith and Anderson (2022) reported that AI can produce unique fabric patterns and design concepts, which designers can then adapt and refine. This application of AI enables faster idea generation and enhances creativity, demonstrating its potential to overcome traditional barriers in design. However, most existing studies focus primarily on professional designers, with relatively limited exploration of how AI may assist beginners or students, particularly within educational contexts.

2.1 *AI in Design Education*

In the field of education, the integration of AI tools to support design students has been examined to varying degrees. A notable study by Gonzalez et al. (2023) examined the use of AI to assist graphic design students during the ideation phase. The AI tool provided a repository of design inspiration and suggestions that students used to overcome creative blocks. The study concluded that students who used AI-assisted tools demonstrated higher creativity in their final projects than those who did not (Gonzalez et al., 2023).

However, Gonzalez et al. (2023) also noted that the AI tool's suggestions occasionally encouraged students to rely excessively on generated outputs, raising concerns regarding the authenticity and originality of their ideas. This highlights the importance of striking a balance between AI assistance and human creativity—an issue that the present study seeks to examine further.

Another relevant case study by Huang et.al. (2024) explored the integration of AI in product design education. Their research highlighted that although AI tools can accelerate the ideation process, they may also pose challenges to students' critical thinking and problem-solving skills. Huang et.al. (2024) recommended adopting a structured approach to AI integration, ensuring that students engage critically with AI outputs rather than passively accepting them.

Despite these promising findings, several gaps remain which this study aims to address. First, there is limited research on how AI can specifically support students in the early stages of the product design process. Most existing studies, such as those by Meng et al. (2024) and Smith and Anderson (2022), focus on the broader creative process without narrowing their scope to the ideation stage. More recently, Berni et al. (2024) suggested conceptualising AI's role in design inspiration and ideation across four phases: ideation, stimulus generation, stimulation, and stimulus searching.

Secondly, the impact of AI on fostering creative thinking among novice designers, particularly within educational settings, has not been comprehensively examined. While Gonzalez et al. (2023) and Huang et.al. (2024) provide valuable insights, their studies do not fully explore how AI can be employed systematically to teach students creative thinking and ideation.

Although AI can enhance the efficiency and breadth of idea generation, its pedagogical value lies in the way it is integrated into creative workflows. This study contributes by focusing specifically on the ideation phase of the product design process, examining not only the outputs but also how students interact with, adapt to, and respond to AI-generated stimuli during their design journey.

2.1 Theory of the design process

In this study, two theoretical frameworks were selected to support the ideation process:

- (i) Design Thinking (IDEO, 2009)
Phases: *Empathise* → *Define* → ***Ideate*** → *Prototype* → *Test*
- (ii) Double Diamond Model (Design Council, 2005)
Phases: *Discover* → *Define* → ***Develop*** → *Deliver*

The Design Thinking framework (IDEO, 2009) emphasises empathy, ideation, and iteration, making it highly suitable for student-centred design. Within the ideation phase, the process explicitly focuses on brainstorming, sketching, and exploring multiple alternatives—activities that align well with the application of generative AI. With the aid of an AI image generator, several low-fidelity concepts and visual directions consistent with user needs were generated.

On the other hand, the Double Diamond Model (Design Council, 2005) situates ideation within the development stage, encouraging divergent thinking before converging on the most appropriate solution. The AI-supported ideation process reflects this divergent–convergent pattern, particularly when students generate stimuli (exploration) and evaluate outputs (refinement). Both frameworks highlight the value of ideation and suggest tools that can support the design process effectively.

Table 1. Framework role of Design Thinking and Double Diamond towards AI contribution for the ideation phase

Framework Role	Focus Area	AI Contribution
Design Thinking	Human-centered empathy, Iterative creativity	AI visualises abstract ideas, stimulates emotion-based ideation, and supports quick prototyping
Double Diamond	Divergence and convergence concept	AI expands idea exploration (divergent) AI aids in concept selection (convergent)

Together, Design Thinking and the Double Diamond provide a dual-lens framework for AI-assisted ideation, ensuring that AI-enhanced ideation remains both exploratory and grounded by merging computational creativity with emotional and human values, thereby aligning with the key competencies required of industrial design students.

3. METHOD

This research adopts a qualitative approach, employing image analysis focused on visual elements such as form, colour, shape, contrast, composition, and other factors critical in early product ideation. The study involves industrial design students with at least two years of experience in design education, ensuring familiarity with the design task. AI image generators —specifically OpenArt and Fotor, both freely accessible—were integrated into the process to assess their impact on ideation. A structured, observation-based design process was implemented to evaluate how AI tools influence creativity.

3.1 Participants

Seven diploma-level industrial design students from Universiti Teknologi MARA, each with at least 2 years of training, were purposively sampled. All participants possessed prior experience with manual ideation techniques but had limited or no exposure to AI-assisted design tools. Their selection was based on their readiness to engage in reflective practice and their familiarity with fundamental design ideation tasks.

3.2 Tools and Procedures

3.2.1 Tools

Two AI image generation platforms, OpenArt and Fotor, were selected for their accessibility and intuitive interfaces. Participants were assigned a design challenge that required them to conceptualise a user-centered product addressing a selected humanitarian issue in Malaysia, such as flooding, haze, or similar challenges.

3.2.2 Procedures for Observation

- i) The study was structured into four phases (Berni et al., 2024), following a systematic approach to ideation undertaken by students:

Phase 1: Manual Ideation (Baseline):

Participants generated initial concepts without AI tools, using sketches and brainstorming techniques.

Phase 2: Stimuli Generation via AI:

Students translated initial ideas into AI-generated prompts, with image outputs serving as divergent stimuli.

Phase 3: Idea Expansion and Refinement:

Participants revised and expanded their ideas through iterative prompting and visual experimentation using AI-generated images.

Phase 4: Design Finalisation

Students selected and refined their final ideas by integrating AI-generated stimuli with their personal design judgement.

- ii) Students began ideation manually through sketching and subsequently by using an AI-assisted tool. The ideation process was carried out in accordance with established design principles, namely balance, contrast, shape, composition, and material.
- iii) The outcomes (images from both processes) were later compared for novelty, functionality, and feasibility.
- iv) Student feedback was collected, and the results were summarised using the AI image evaluation rubric, along with data from interview sessions.

3.2.3 Procedures for the Interview

- i) A semi-structured interview was conducted individually and online with all seven students after the observation session.
- ii) Each student was asked to provide feedback on their experience of producing ideation using an AI image generator.

- iii) All questions focused on three areas of product ideation: form, function, and feasibility.
- iv) All responses were recorded and analysed accordingly using thematic analysis.

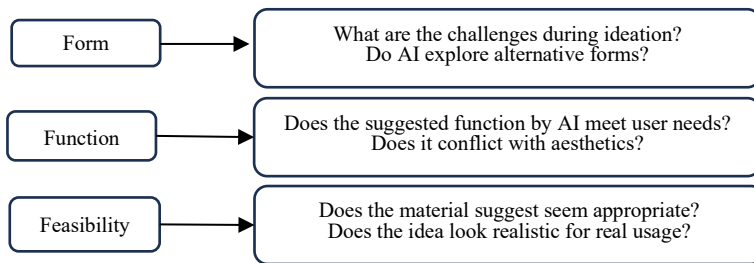


Fig. 1. Interview Guide

3.3 Analysis

An AI image evaluation rubric for product design ideation was developed based on established scholarly principles: (i) novelty (Shah et al., 2003), (ii) variety (Purcell & Gero, 1998), and (iii) usability (Amabile, 1996), along with aesthetic value (Desmet & Hekkert, 2007), AI stimulus response (Kwon et al., 2023), and visual clarity (Tovey et al., 2003) in design creativity and ideation studies. Rather than being adopted directly from a single scholar or published rubric, the framework synthesises multiple perspectives. Scores were rated on a scale of 1 to 5 for each criterion.

Table 2. AI image Evaluation Rubric

Criteria	Description
Form Innovation (Novelty)	Originality of form, shape, deviation from conventional product types.
Visual Appeal (Aesthetics)	Harmony, composition, style, material texture, and overall attractiveness.
Functionality Potential	Whether the image implies a feasible product use or affordance.
Inspiration Level	The degree to which the image inspires new ideas, supports imagination, or generates further concepts.
Alignment with Design Brief	Relevance to product category, design task or theme.
Usability for Concept Development	Ease of extracting usable elements for sketches or concept refinement.

Table 3. Scoring Indicators

Total Score	Interpretation
25–30	Highly inspirational and usable image
19–24	Useful with minor limitations
13–18	Moderate inspiration; needs refinement
Below 13	Low value as ideation aid

Note: Adapted from various creativity and design ideation assessment frameworks, including Shah et al. (2003), Amabile (1996), Desmet & Hekkert (2007), and recent AI-ideation studies (e.g., Kwon et al., 2023; Berni, 2021).

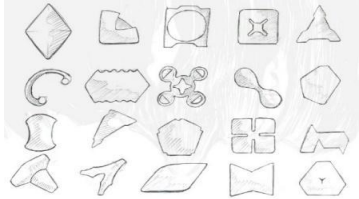
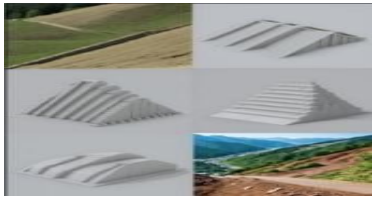
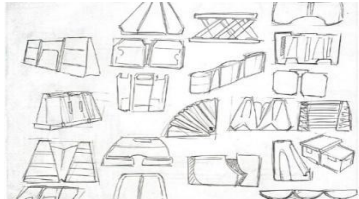

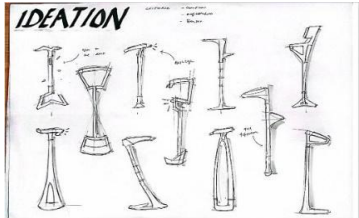



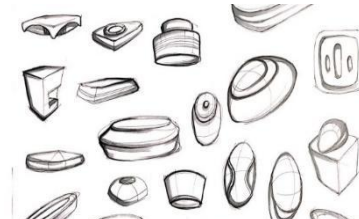

The rubric underwent content validation by four design experts, experienced in industrial design and creative pedagogy, from the collaborating university, to ensure that the criteria reflected recognised principles of creative ideation and design usefulness. The Scale-Level Content Validity Index (S-CVI) was calculated, with S-CVI ≥ 0.90 regarded as the acceptance threshold. Reliability evidence was obtained through a pilot scoring session involving multiple raters ($n = 3-5$), who independently evaluated AI-generated images using the rubric. Internal consistency reliability was examined using Cronbach's alpha, with $\alpha \geq 0.70$ considered satisfactory. These analyses confirmed that the rubric could be applied consistently and objectively across raters.

4. FINDINGS & DISCUSSION

The results are presented as findings from each phase.

4.1 Observation Results

Observation data were compiled using a comparative table between manual ideation and AI-generated ideation. Notable differences were categorised into themes, including generated forms, functions, and contextual environments.

Participant	Ideation without AI (Manual Sketching)	Ideation with AI Image Generator
Student 1		
Student 2		
Student 3		
Student 4		
Student 5		

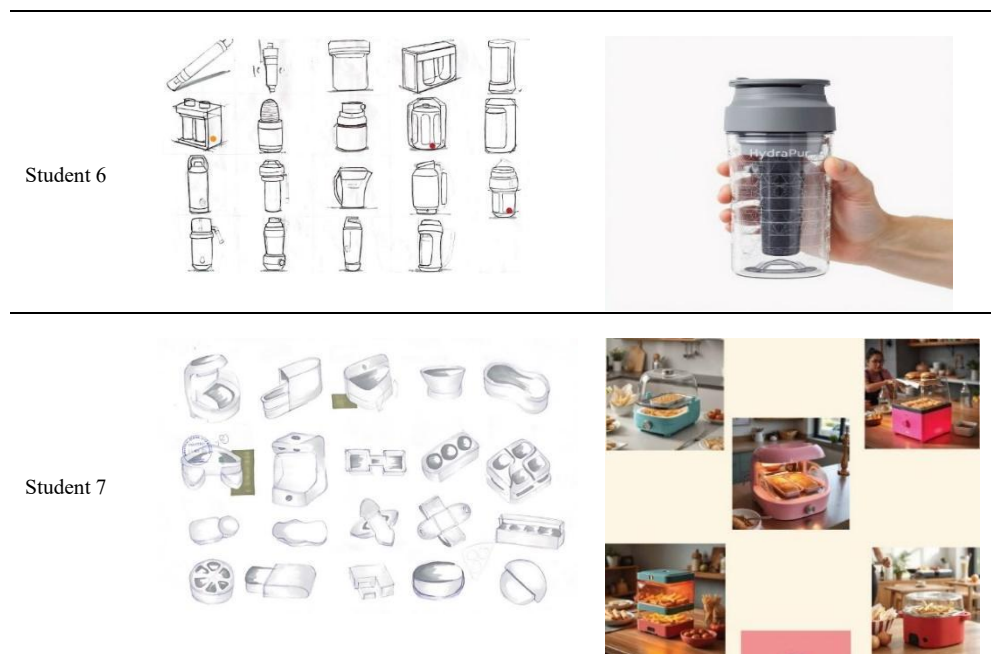


Fig. 2. Ideation images: manual versus AI-generated applications (Source: Participants)

From the AI-generated images, all six criteria were rated according to the evaluation rubric (see Table 2).

Table 5. AI-Generated Image Scores

Criteria	S1	S2	S3	S4	S5	S6	S7	Total
Visual Appeal / Aesthetics	2	3	2	4	4	3	3	21
Form Innovation / Novelty	2	2	2	4	4	2	3	19
Functionality Potential	2	3	3	4	4	3	3	22
Inspiration Level	2	3	3	4	4	3	3	22
Alignment with Design Brief	1	3	3	4	4	3	3	21
Usability for Concept Development	1	3	3	4	4	3	3	21
Total	10	17	16	24	24	17	18	

The results indicated that none of the AI-generated image scores exceeded 25, which would represent a highly inspirational and usable image. Two students achieved scores of 24, interpreted as applicable with minor limitations; four students obtained scores between 16 and 18, categorised as moderate inspiration requiring refinement; and one student scored 10, indicating a low value as an ideation aid. This finding supports the contribution of AI to fostering more innovative and diverse solutions in design students' ideation processes (Meng et al., 2024). Furthermore, all six observed elements scored between 19 and 22, suggesting that AI use was practical with minor limitations.

4.2 Interview results

In addition, the interview findings revealed that participants experienced challenges during Phase 1 of the ideation stage, although AI significantly expanded their creative possibilities in Phase 2. In Phase 3, AI supported the iterative refinement process; however, some participants encountered difficulties incorporating AI-generated stimuli into their concepts. By Phase 4, the majority expressed that AI-assisted ideation was advantageous, although concerns regarding over-reliance on AI persisted. The interview therefore provides valuable feedback on the challenges students faced throughout the ideation process.

Table 6. Observation results

Criteria	Codes (Challenges)
Form	Minor alternative ideas, enhance originality, unusual ideas, unique combination, conceptual, assistance form
Function	Follow criteria, user experience, fit the environment, same reference, user-centred, people's experience, user knowledge
Feasibility	Inspired, visually compelling, innovative patterns, improve accuracy, alternative colour and design, understandable, interesting

Based on Tables 5 and 6, several themes emerged regarding the use of AI applications during the ideation phase of product design. These were categorised into three key areas: form, function, and feasibility.

Theme 1: Creativity Level

The ideation phase requires the ability to think creatively about a product's overall features. At this stage, a new form suggested by AI scored 19, which indicates only minor changes to form. Challenges frequently arise in visualising new shapes, maintaining originality, and balancing aesthetics with usability. When AI tools are introduced, they act as creative catalysts, enabling students to visualise unconventional combinations and rapidly explore new directions (Kim & Maher, 2023). These tools often generate unexpected aesthetics or structural variations that students would not have conceived independently, thereby broadening the scope of ideation (Berni et al., 2024).

Theme 2: Idea Quantity

A wide variety of forms is necessary to identify the most suitable design at an early stage. AI assistance generates unique ideas and combinations of shapes, resulting in more ideation outcomes. Idea quantity also depends on the designer's level of creativity. The abundance of options empowers students to select and refine the most promising concepts, thereby increasing the efficiency and depth of exploration (Liu et al., 2021). This process discourages premature fixation on initial ideas and instead encourages evaluation of a wider range of possibilities, which is a defining characteristic of creative expertise (Runco, 2004).

Theme 3: User-Emotion Consideration

Designers often struggle to translate ideas into usable solutions or to integrate features that meet user needs. In the early stages of ideation, attention is usually focused on form and function (Cross, 2011), with emotion rarely considered. By incorporating AI, students may address emotion earlier in the design process, particularly during prompting. They can evoke different moods or cultural narratives, encouraging reflection on how design affects users psychologically (Gonzalez et al., 2023).

Theme 4: Time Efficiency

Manual ideation is often time-consuming, with ideas refined sequentially and without external stimuli. AI streamlines the process by enabling rapid refinement through iterative prompting (Huang et al., 2024). This allows students to dedicate more time to critical evaluation during idea development. Furthermore, the immediate visual outputs from AI help students identify clearer design directions and avoid familiar or weak concepts at the outset of the process.

Theme 5: Originality Concerns

During manual ideation, students often reproduce existing or familiar designs, while also expressing concern about the authorship and authenticity of AI-generated outcomes. This highlights their role as curators and interpreters of AI-generated material during the prompting process (Huang et al., 2024). It is

therefore essential to develop responsible strategies for training design students to use AI as an assistive tool in ways that maintain originality and uphold ethical design practices.

5. CONCLUSION

AI applications are being rapidly developed worldwide and implemented across a wide range of industries, including design, where they increasingly assist design-related tasks. To ensure that education keeps pace with technological advances, this study explored the use of AI applications for learning purposes, particularly within the design process. Students were introduced to AI tools at the earliest stage of the design process, as the initial phase of generating ideas is often the most complex to undertake.

The ideation phase challenges students to apply their design knowledge while integrating AI capabilities. From the students' experiences, several themes were identified. The AI-generated ideation images consistently highlighted the three fundamental elements of product design: form, function, and feasibility. Generally, the forms generated by AI appeared as complete three-dimensional representations, portrayed in diverse variations and perspectives depending on the given prompt, whether geometric or organic. These images also included suggested colour schemes. Secondly, the AI-generated outputs frequently displayed details of the product's components, enabling students to envisage functionality and consider how these suggested elements could be incorporated into ideation. The inclusion of detailed features such as buttons, screws, and fittings further enhanced the usability of the outputs. Thirdly, the AI-generated images often situated the products within contextual environments that were visually appealing, enabling students and potential audiences to imagine real-world applications.

In practice, the experience of using AI in the early design process revealed several important considerations: students' creativity levels, the quantity of ideas generated, the integration of user emotions at the initial stage, improvements in time efficiency, and concerns regarding the originality of the work. These are key factors that students must anticipate when working with AI. This research focused primarily on students' experiential use of AI, rather than on its technical mechanisms. Nevertheless, the AI image generator addressed approximately 90% of the requirements of the ideation phase, confirming its value as a tool to support design creativity.

Looking ahead, institutional awareness and encouragement for students to implement AI in design projects should be cultivated, supported by appropriate guidance and procedures. Numerous studies have been conducted, and the various findings and recommendations are expected to be applied effectively. Future experimental research using AI in design could further explore its effects on design behaviour itself.

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CONFLICT OF INTEREST STATEMENT

The authors confirm that this research was conducted in the absence of any personal benefits, commercial, or financial conflicts of interest, and declare no conflicts of interest with the funders.

AUTHORS' CONTRIBUTIONS

Nurhikma Mat Yusof conducted the research, drafted, and revised the manuscript. Rosaliana Rahim conceptualised the central research idea and provided the theoretical framework. Azni Hanim Hamzah and Nadia Sigi Prameswari designed the research and supervised its progress. Deny Willy Junaidi coordinated the review, contributed to revisions, and approved the final manuscript for submission.

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