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Artificial Intelligence (AI)-Aided Collaborative Design in Industrial Design Education for Final Year Projects (FYP)

Improving Workflow and Innovation

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Abstract

The integration of Artificial Intelligence (AI) into design education is transforming collaborative learning and creative practice, particularly in Industrial Design. A theoretical framework was developed through the literature review to guide this study, which investigates how AI-assisted tools influence creativity, collaboration, and workflow efficiency in Final Year Projects (FYPs) among 38 Industrial Design students at a Malaysian university. Employing a mixed-methods design, two classes participated in a quasi-experimental comparison: one integrated AI tools throughout the design process, while the other used traditional methods. Students applied AI tools across five project phases: research (Notion AI, Elicit), ideation (DALL·E, MidJourney), design simulation (Fusion 360 AI, Rhino AI), reporting (ChatGPT, Grammarly), and prototyping (generative design tools). Quantitative data from project rubric scores and supervisor evaluations were complemented by qualitative insights from reflective journals and focus group discussions. Results showed that the AI-assisted class achieved higher creativity and design quality, supported by enhanced efficiency and faster iteration. However, students also reported challenges related to over-reliance on AI, ethical concerns about authorship, and reduced hands-on engagement. The study concludes that AI can serve as a valuable cognitive and creative partner in design education when integrated within a reflective and human-centered pedagogical framework that maintains critical thinking, originality, and ethical responsibility.

Keywords: AI-Aided Design, Collaborative Design, Industrial Design education, Final Year Project (FYP), Human-AI Collaboration, Human-Centered Design

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Introduction

The integration of Artificial Intelligence (AI) in higher education, particularly within creative and design-oriented disciplines, is transforming both pedagogical strategies and design practices (Al-Zahrani and Alasmari 2024). Industrial Design education is distinct from many other programs due to its reliance on studio-based learning, project-driven collaboration, and iterative prototyping (Oxman 2006). Students must balance aesthetic, functional, and human-centered considerations, translating abstract ideas into tangible outcomes. This combination of creative reasoning and technical execution positions Industrial Design as a discipline that can both benefit from and critically interrogate AI integration.

Collaborative projects, particularly Final Year Projects (FYPs), are central to preparing students for real-world design challenges (Deighton et al. 2024). These projects require multidisciplinary coordination, iterative development, and conceptual innovation, often under tight time and resource constraints. Traditional collaborative workflows can be inconsistent, relying heavily on communication and the individual skills of group members, which may affect project outcomes and learning experiences.

In this study, the FYP were developed under the theme "AI-Aided Design for Inclusivity." The theme emphasized using AI to support inclusive apnd accessible design by gathering and analyzing diverse user data to inform design decisions. Students applied AI tools to propose solutions that address varying user abilities and backgrounds while considering sustainable materials and eco-friendly production methods. This approach encouraged the integration of technology, empathy, and sustainability within the collaborative design process.

AI tools offer potential to augment multiple stages of the design process, including automating repetitive tasks, generating concept visuals, and supporting generative modeling (Lorenc-Kukuła 2025). Platforms such as ChatGPT, DALL·E, and AI-assisted CAD tools are increasingly explored by students to support ideation, visualization, and collaborative problem-solving. The selection of these tools in this study was guided by their alignment with the learning objectives of Industrial Design education, their accessibility to students, and their demonstrated utility in supporting creative workflows (Zhou and Peng, 2025; Melker et al. 2025).

The integration of AI in collaborative learning environments also carries discipline-specific risks. Overreliance on AI-generated outputs may reduce critical thinking, originality, and hands-on craftsmanship. Ethical concerns—such as authorship attribution, data bias, and the diminishing of material engagement—are particularly salient in a field rooted in human creativity and tactile problem-solving. These factors highlight the need for structured pedagogical frameworks that integrate AI in ways that support reflective thinking, iterative design, and equitable collaboration (Parveen et al. 2024).

This study therefore investigates how structured AI use can enhance collaborative workflows and innovation in final-year Industrial Design projects. By focusing on the Malaysian higher education context—where AI adoption in design curricula remains emerging—this research examines both the pedagogical opportunities and challenges of embedding AI into collaborative design learning. The primary objective is to explore the impact of AI-assisted tools on students' collaborative design processes, with particular emphasis on workflow efficiency, creativity, and innovation. The central research question guiding this study is: How does the integration of AI tools affect collaborative workflows and innovation processes in final-year Industrial Design projects?

By addressing this question, the study contributes to the growing discourse on AI in education, offering discipline-specific insights into collaborative learning with AI, informing curriculum design, and proposing strategies to balance AI support with critical engagement, creativity, and reflective practice in Industrial Design education.

Literature Review and Theoretical Framework

The increasing incorporation of Artificial Intelligence (AI) in design education has introduced new dynamics in creativity, collaboration, and user-centered innovation. In the context of Industrial Design, AI technologies are progressively reshaping how students conceptualize, prototype, and evaluate their design outputs (Zhou and Peng 2025; Melker et al. 2025). However, to effectively guide this integration, a robust theoretical framework is necessary to ensure that AI use remains grounded in human values, empathy, and iterative learning. To this end, this study is underpinned by Norman's Human-Centered Design (HCD) framework (Norman 2013).

According to Norman (2013), the HCD framework emphasizes designing with a deep understanding of users' needs, abilities, limitations, and contexts of use. The approach promotes a cyclical, iterative process involving observation, ideation, prototyping, and testing, where user feedback and contextual awareness drive design improvement. Within this paradigm, technology serves as an enabler, not a replacement for human creativity or judgment. Applied to Industrial Design education, the HCD framework underscores the importance of empathy, reflection, and collaborative problem-solving—skills that are essential for inclusive and socially responsible design practices (Oxman 2006; Deighton et al. 2024).

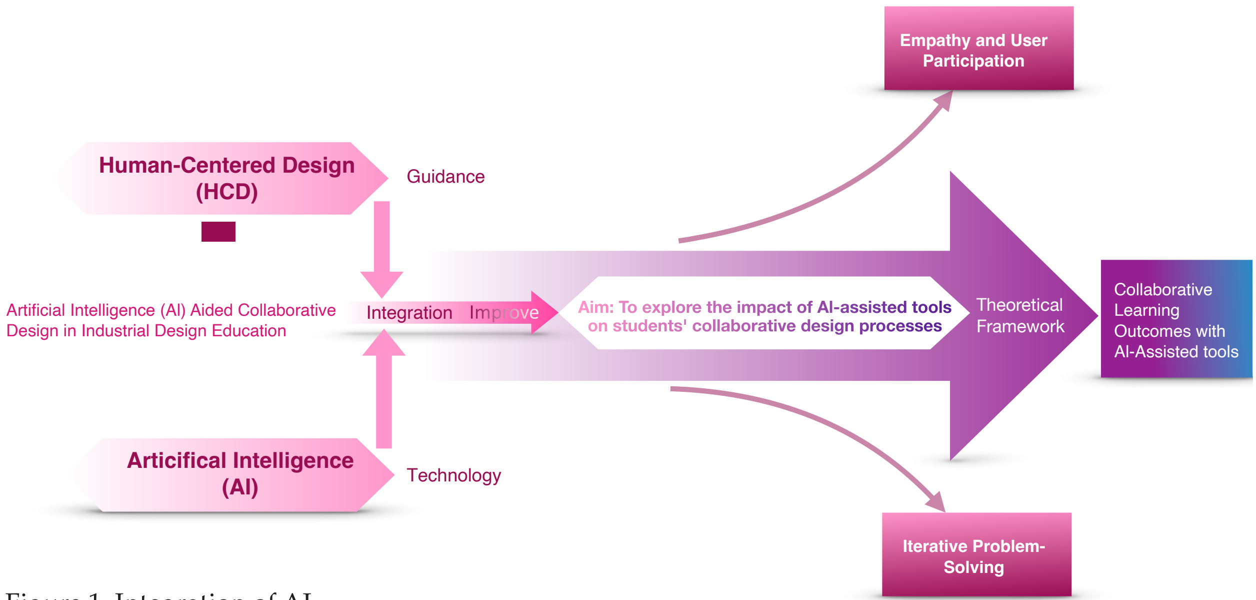

Figure 1. Integration of AI Tools within Norman's Human-Centered Design Framework for Collaborative Industrial Design Education

Figure 1 illustrated the theoretical framework on Integration of AI Tools within Norman's Human-Centered Design Framework for Collaborative Industrial Design Education. By integrating Norman's HCD framework, this study situates AI not merely as a productivity enhancer but as a supportive element within human-centered learning and design processes, HCD provides pedagogical guidance, while AI offers technological support in Industrial Design education, with the aim of exploring the impact of AI-assisted tools on students' collaborative design process. This theoretical lens enables the analysis to explore how AI-assisted tools can enhance inclusivity, creativity, and decision-making within Final Year Projects (FYPs). The application of HCD thus ensures that technological advancements remain aligned with pedagogical and ethical imperatives that prioritize human creativity, empathy, and reflective practice.

Methodology

Research Design

This study employed a mixed-methods research design, which was appropriate for examining both the measurable and experiential dimensions of AI integration in Industrial Design education (Creswell 2014). As illustrated in Figure 2, the research was conducted in two

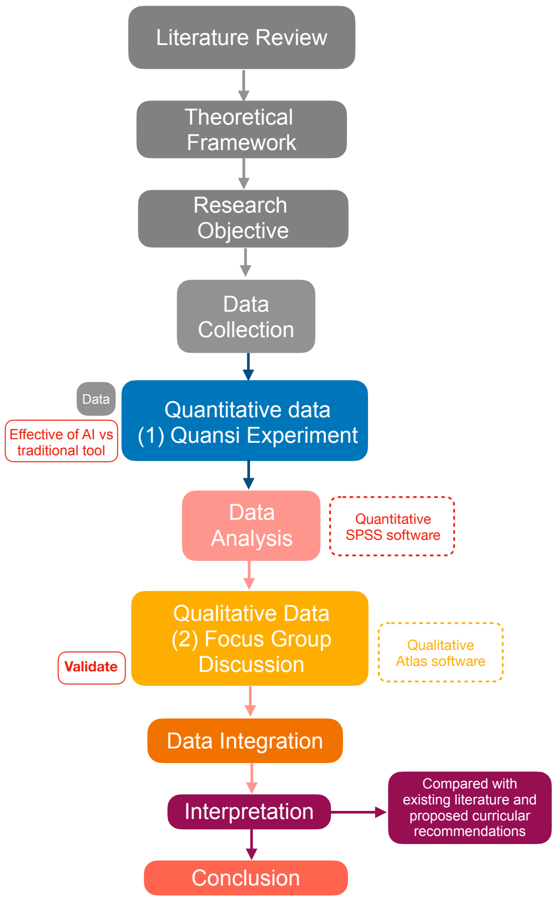

Figure 2. Flow of research design

phases. The first phase involved a quantitative quasi-experimental design, focusing on evaluating project outcomes to determine the effects of AI-assisted tools on students' collaborative workflows. Project performance was assessed through formal rubric evaluations based on criteria such as design quality, creativity, efficiency, and the extent to which AI contributed to the overall process.

Following the quantitative phase, a qualitative inquiry was undertaken to explain and expand upon the statistical findings. This phase explored students' perceptions, challenges, and experiences with AI tools through reflective journals and focus group discussions, complemented by faculty observations. The qualitative insights provided a deeper understanding of how AI influenced collaboration, ideation, and innovation during the Final Year Projects (FYPs) (Sobaih et al. 2025). The sequential integration of quantitative and qualitative data allowed for a comprehensive interpretation of the pedagogical implications of AI-aided collaborative design, offering both empirical evidence and contextual understanding of its impact on Industrial Design education.

Participants and Context

This study was conducted at a Malaysian public university that has recently introduced emerging technologies, including Artificial Intelligence (AI), into its Industrial Design curriculum. The participants comprised 38 final-year Industrial Design students (mean age = 23.1 years) enrolled in a mandatory capstone course that forms the culmination of their academic program. These students undertook a semester-long Final Year Project (FYP) under the theme "AI-Aided Design for Inclusivity," which encouraged the use of technology to support human-centered, creative, and sustainable design practices.

For the quantitative phase, the students were organized into two classes, each consisting of 19 students. One class functioned as the AI-assisted group, integrating selected AI tools throughout the research, ideation, development, and reporting stages of their projects. The other class served as the traditional group, completing their projects using conventional design methods without AI assistance. This quasi-experimental design enabled a comparative analysis of how AI integration influenced workflow efficiency, creativity, and collaboration in the design process.

In the qualitative phase, both classes participated in focus group discussions and maintained reflective journals to provide deeper insight into their learning experiences. These qualitative data helped explain and contextualize the quantitative findings, revealing how students perceived the benefits and challenges of AI integration within collaborative design projects. Together, the two phases provided a comprehensive understanding of how AI-assisted tools impact creativity, teamwork, and innovation in Industrial Design education.

Instruments and Tools

To assess the impact of AI tools on the collaborative design process in final-year Industrial Design projects, this study employed a combination of AI tools across five key project stages and a set of data collection instruments. These tools and instruments were integral in evaluating the efficiency, creativity, and effectiveness of AI in enhancing the students' workflows. These tools were strategically integrated into the following project phases as listed in Table 1.

Project Phase	AI Tools Used	Purpose
Research & Ideation	Notion AI, Elicit, DALL·E, Mid Journey	Organizing literature, generating questions, and visual mood boards
Design Development	Fusion 360 AI, Rhino AI	Generative modelling, structure simulation
Writing & Documentation	ChatGPT, Grammarly	Report drafting, grammar, and language improvement
Prototyping	Autodesk Generative Design, Dream Fusion	Form optimization and AI-assisted fabrication

Table 1. AI Tools Used in Each Project Phase

Throughout the project, AI tools were strategically integrated across phases to improve efficiency and foster creativity, as Figure 3 illustrates the design process. In the Research & Ideation phase, Notion AI and Elicit supported literature synthesis and research question development, while DALL·E and Mid Journey generated visual mood boards and concept imagery to inspire design exploration. During Design Development, Fusion 360 AI and Rhino AI enabled generative modelling, structural simulation, and design optimization, assisting students in visualizing complex forms and assessing feasibility. In the Writing & Documentation phase, ChatGPT facilitated report drafting and refinement, while Grammarly ensured linguistic accuracy and professional tone (Zhu et al., 2024). In the Prototyping phase, Autodesk Generative Design and Dream Fusion aided in form optimization and AI-assisted fabrication, streamlining the transition from digital models to 3D-printed prototypes. Collectively, these tools enhanced the design workflow from initial concept to final output (Ma et al. 2023).

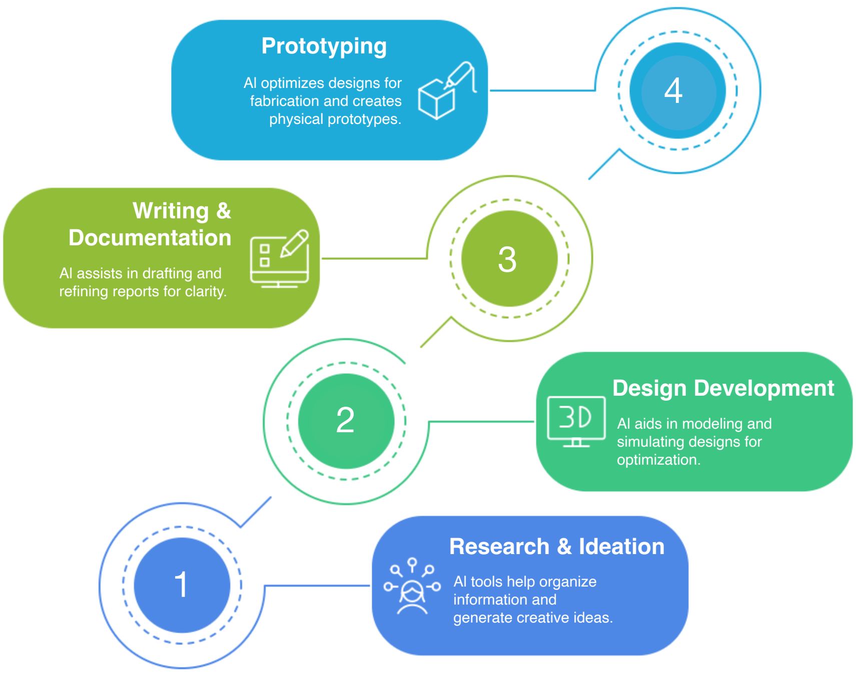

Figure 3. AI-Aided design process

Data Collection

Data were collected in two sequential phases—quantitative followed by qualitative—to provide both measurable and experiential insights into the impact of AI tools on the collaborative design process. The overall data collection process is illustrated in Figure 4 (next page).

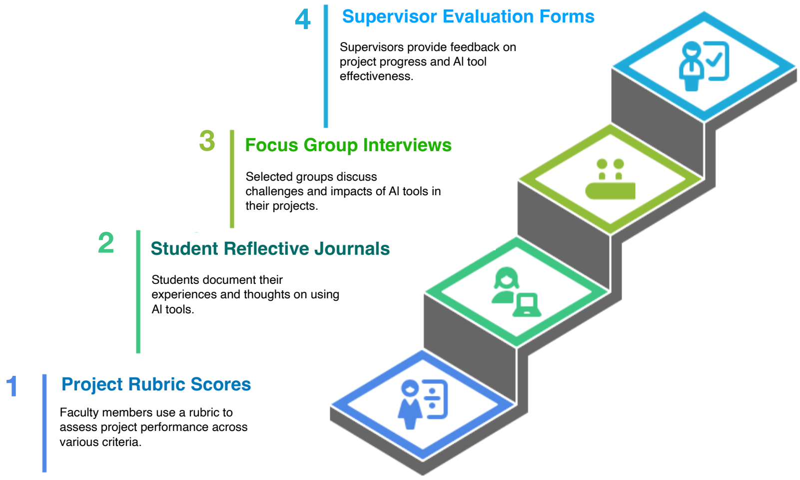

Figure 4. Data collection process for evaluating AI tools in the collaborative design process

In the quantitative phase, data were obtained through Project Rubric Scores, which provided an objective measure of each class's project performance. Faculty evaluators assessed both the AI-assisted and traditional classes using a standardized rubric based on five key criteria: design quality, creativity, functionality, collaboration, and technical execution, rated on a 0–100 scale (Costa 2024). This quantitative data enabled direct comparison of the two instructional conditions and allowed the study to evaluate the measurable influence of AI tools on design outcomes. Supervisor Evaluation Forms were also used to capture instructors' observations on project progress, teamwork dynamics, and the practical effectiveness of AI tools in facilitating design workflows.

In the qualitative phase, data were gathered to explain and expand upon the quantitative results. Students from both classes participated in Structured Reflective Journals, submitted weekly throughout the semester. These journals, following guided prompts, invited students to describe their experiences with collaboration, the perceived role of AI in creativity and problem-solving, and challenges encountered during the design process (Sudirman et al. 2024; Schimpf et al. 2024). The structured format ensured consistency and facilitated thematic comparison across participants.

To complement the journals, Focus Group Interviews were conducted with selected representatives from both the AI-assisted and traditional classes. These sessions were specifically designed to capture the social and collaborative dynamics of AI tool use—how students debated ideas, negotiated shared understandings, and collectively critiqued AI-generated outputs within their teams. The interviews explored students' perceptions of AI integration, its influence on teamwork and creativity, and the balance between technological support and human decision-making. The interview guide was adapted from Tripathi and Smriti (2025), who examined students' experiences with AI in higher education, and was reviewed by two design education experts to ensure contextual relevance and clarity.

Together, these quantitative and qualitative instruments provided a comprehensive dataset for triangulation, allowing the study to analyze pnot only the measurable differences between AI-assisted and traditional design processes but also the underlying perceptions, behaviors, and collaborative experiences that shaped those outcomes.

Data Analysis

The data collected from both quantitative and qualitative instruments were analyzed sequentially to provide a comprehensive understanding of the impact of AI tools on collaborative design processes in Industrial Design education. Consistent with the sequential explanatory mixed-methods design, the quantitative analysis was conducted first to identify measurable differences between the AI-assisted and traditional classes, followed by qualitative analysis to explain and contextualize those findings.

In the quantitative phase, data from the Project Rubric Scores and Supervisor Evaluation Forms were analyzed to assess project outcomes across five dimensions: design quality, creativity, functionality, collaboration, and technical execution. Each criterion was evaluated on a scale from 0 to 100, with higher scores indicating better performance. Descriptive statistics—including mean, median, and standard deviation—were computed to summarize the data and identify overall trends. The mean rubric score for the AI-assisted class was 85.4, while the traditional class scored 78.3, indicating higher overall performance among students who used AI tools. The standard deviation for the AI-assisted class (5.2) was lower than that of the traditional class (7.4), suggesting more consistent results among AI users.

An independent samples t-test was then applied to determine whether these differences were statistically significant. Results showed that the AI-assisted class performed significantly better in design quality and creativity (p = 0.03), while no significant differences were observed in functionality and technical execution (p = 0.18). These findings indicate that AI tools had a more substantial impact on the creative and innovative dimensions of design learning, whereas technical outcomes remained comparable between the two instructional approaches.

In the qualitative phase, data from Student Reflective Journals and Focus Group Discussions were analyzed using the six-phase reflexive thematic analysis process described by Naeem et al. (2023). This process involved familiarization with the data, generating initial codes, developing and refining themes, and defining their meanings to ensure analytical rigor and transparency. The qualitative analysis provided deeper insight into how students experienced and perceived the integration of AI tools during their Final Year Projects. Four major themes emerged from the analysis—efficiency, creativity, tool limitations, and ethical concerns—which helped explain the quantitative results and illustrated the broader pedagogical and experiential impact of AI-assisted learning.

Finally, findings from both phases were integrated to develop a holistic interpretation of AI's influence on design education. Quantitative results demonstrated measurable improvements in creative performance, while qualitative insights revealed how AI tools shaped students' collaborative behaviors, reflective practices, and ethical considerations. This integrated interpretation strengthened the overall validity of the study by connecting objective outcomes with subjective experiences.

Results and Discussion

This section presents the findings from both the quantitative and qualitative phases of the study, highlighting the impact of Artificial Intelligence (AI) tools on collaboration, creativity, and efficiency in Industrial Design Final Year Projects (FYPs). Consistent with the sequential explanatory mixed-methods design, the **quantitative re-**

sults are presented first, followed by **qualitative insights** that explain and expand on these findings.

Quantitative Results

The analysis of **Project Rubric Scores** revealed that the **AI-assisted class** achieved higher overall performance than the **traditional class** across most assessment criteria. The mean rubric score for the AI-assisted class was **85.4**, compared to **78.3** for the traditional class. An independent samples t-test confirmed that these differences were statistically significant in **design quality and creativity** ($p = 0.03$), but not in **functionality** or **technical execution** ($p = 0.18$). This indicates that while AI integration enhanced creative ideation and workflow efficiency, it did not necessarily improve technical or engineering precision.

Supervisor evaluations supported these findings, noting that AI-assisted students demonstrated greater fluency in idea development and faster iteration cycles, particularly during the ideation and prototyping stages. However, supervisors also observed that some students displayed **over-reliance on AI outputs**, occasionally neglecting the refinement and manual problem-solving typically expected in design studio practice.

Qualitative Findings

The **qualitative phase**—drawing from student reflective journals and focus group discussions—offered deeper insights into how students experienced and interpreted AI use in their projects. Thematic analysis (Naeem et al. 2023) identified **four recurring themes**: **efficiency, creativity, tool limitations,** and **ethical concerns** (see Figure 5, next page).

Students in the AI-assisted class consistently reported increased **efficiency**, emphasizing that AI tools such as *Notion AI*and *Elicit* helped streamline literature review, organize design data, and generate early research insights. Many noted that these tools “saved time” and “reduced repetitive tasks,” allowing more focus on ideation and design refinement. However, a few students acknowledged a tendency to rely too heavily on AI-generated content, which sometimes limited their own analytical depth and critical engagement.

The theme of **creativity** reflected both positive and cautious perspectives. Students widely agreed that tools such as *DALL·E* and

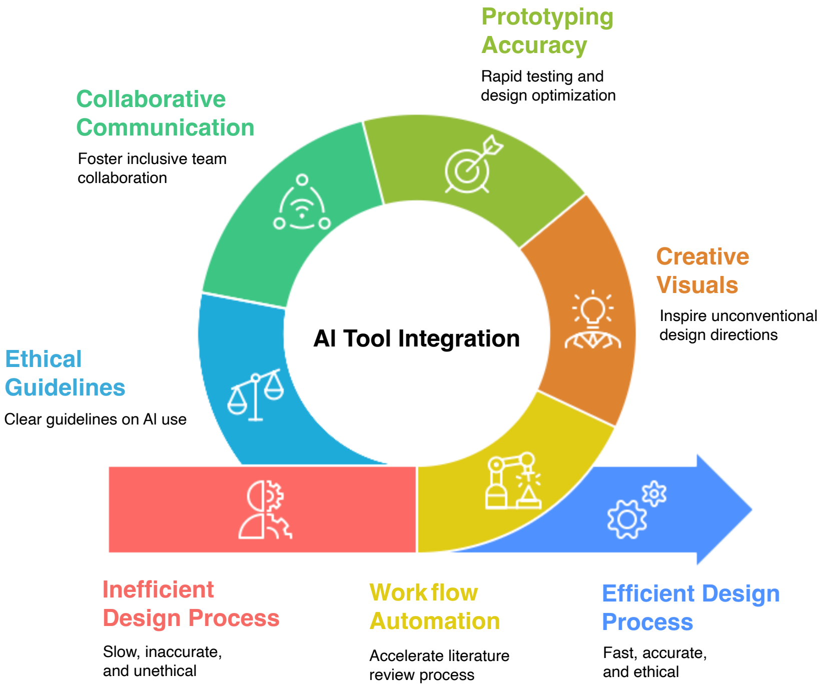

Figure 5. Recurring patterns and themes of AI in design education

MidJourney expanded their creative possibilities, enabling them to visualize unconventional forms and explore aesthetic variations that might not have emerged through manual sketching alone. Yet, some participants expressed concern that AI-generated imagery felt "too similar" or "algorithmically biased," reducing originality and personal expression—echoing findings by Kulishova and Sajek (2025). These mixed reactions underscore the dual nature of AI as both an enabler and a constraint within creative processes.

Regarding **tool limitations**, students described technical challenges when using platforms such as *Fusion 360 AI* and *Rhino AI*, especially when modeling complex geometries. In several cases, AI-generated forms required significant manual correction to meet design specifications, which occasionally negated time savings. Despite this, most participants appreciated the ability of AI to visualize structural feasibility quickly, leading to more confident design decisions.

Finally, **ethical concerns** emerged as a prominent theme. Students questioned issues of authorship, originality, and the potential for plagiarism in AI-generated content. Some worried that AI tools might reproduce existing designs or blur the boundary between individual and algorithmic creativity. These concerns reinforce calls for integrating **AI literacy and ethical training** within design curricula to ensure responsible use of such tools (Pasquinelli et al. 2023).

Integrated Discussion

Integrating findings from both phases provides a holistic understanding of AI's role in collaborative design education. The quantitative data established that AI integration significantly improved creativity and efficiency, while qualitative insights explained **how** and **why** these gains occurred—through faster ideation, enhanced visualization, and data-supported decision-making (Tan et al. 2024; Tammisto 2025). At the same time, qualitative evidence illuminated the **human factors** that quantitative scores could not capture, such as dependency on AI, reduced hands-on engagement, and ethical uncertainty (Kobe et al. 2022).

As figure 5 illustrated. These results align with prior research suggesting that AI augments design workflows by facilitating rapid iteration and exploration (Zhou and Peng 2025; Melker et al. 2025), but also introduce new pedagogical challenges regarding critical reflection and authorship (Parveen et al. 2024). Overall, the findings underscore that AI can serve as a powerful cognitive partner in design education when used within a **structured, reflective, and human-centered framework**—such as Norman's (2013) Human-Centered Design (HCD) model. This alignment ensures that AI supports rather than supplants human creativity, fostering balanced, ethical, and innovative design learning environments. The study demonstrates that AI's success is contingent on its role as a subordinate tool within a human-centric process. When it accelerates ideation and handles repetitive tasks, it aligns with HCD by freeing the designer to focus on user empathy and complex decision-making. Conversely, when its use leads to uncritical adoption, it undermines the very human values that HCD seeks to prioritize. Therefore, the HCD model provides not just a pedagogical guide but also a critical metric for evaluating the appropriate integration of AI, ensuring it supports rather than supplants human creativity.

Conclusion

This study concludes that the structured integration of Artificial Intelligence (AI) tools in Industrial Design Final Year Projects (FYPs) significantly enhances workflow efficiency, fosters creativity, and elevates design outcomes. Our findings demonstrate that AI serves as a powerful cognitive partner, accelerating research, ideation, and prototyping, which allows students to dedicate more effort to conceptual development and collaborative refinement.

However, this potential is tempered by significant pedagogical risks, including over-reliance that can diminish originality, reflective thinking, and hands-on craftsmanship. Ethical concerns regarding authorship and data privacy further complicate its adoption. Grounded in Norman's Human-Centered Design (HCD) framework, this study posits that AI must function as an enabler of human creativity, not a replacement for it.

The primary practical contribution of this research is an evidence-based model for integrating AI within a reflective, human-centered pedagogical structure. To operationalize this, we propose that Industrial Design education must move beyond ad-hoc tool adoption and formally incorporate AI competency and critical evaluation modules into the curriculum. These modules should guide students to use AI not as an oracle, but as a provocation—a tool to be critically interrogated and thoughtfully integrated within the iterative design process.

For educators and curriculum designers, this study provides a clear framework and a set of critical considerations for harnessing AI's benefits while mitigating its risks. Future longitudinal research is needed to examine the long-term impacts on skill development. By anchoring AI integration in the core values of empathy, critical thinking, and originality, Industrial Design education can strategically evolve to embrace technological innovation without compromising its human-centric foundation.

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