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SYNERGISTIC DESIGN: THE FUSION OF GENERATIVE AI AND CONVENTIONAL IDEATION APPROACHES

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ABSTRACT
Traditional ideation techniques used in complex engineering design challenges have long been practiced. However, with the advent of generative AI, many supporting tools have emerged, some of which attempt to mimic cognitive processes. Exploring how AI tools can be integrated into the early design phase, an ideation bootcamp was set up as an inspirational source early in a full-semester, 20-week advanced engineering design project course. This session explored the input values derived from a human-centred collaborative technique known as "Brainwriting," alongside two types of AI tools, where one focused on text generation and the other on visual outputs. The activity highlighted the considerable potential of combining human creativity with machine intelligence. A total of 22 fifth-year engineering design students engaged in a multifaceted ideation process, beginning with the Brainwriting exercise using traditional pen and paper, before progressing to experiment with the AI-powered tools Copilot (text and visuals) and Vizcom (visuals). This iterative refinement process was highly valued by the majority of students in the advanced product development course, particularly as most had limited or no prior experience using such tools in a comprehensive design context. The findings suggest that integrating AI-powered tools into human-centred product-service system design education is not just a trend but a necessity. It allows for a more efficient, creative, and iterative design process, empowering students to harness the power of AI to develop innovative solutions. The bootcamp demonstrated that combining traditional methods with AI-driven approaches can be both fun and enriching, fostering a dynamic learning environment.

Keywords: Ideation, generative AI, brainwriting, design education, AI design

1 INTRODUCTION
Artificial intelligence (AI) initiatives are often characterised by extensive, explorative purposes where existing challenges resides in recognising it as a capability that offers significant potential [1]. In order to make use of efforts being made research has looked at the importance of selecting the right moment and making critical context estimation for how to make proper use of AI integration [2]. AI profoundly transforms 'educational ecosystems' by enhancing testing and exploration [3], but it is essential to balance these advancements with careful assessment and ethical considerations. This way AI adds an influencing knowledge-sharing approach to learning and presents a challenge to how collaborative and cognitive processes may be designed [4]. In the context of higher education, and more specifically design education AI is perceived as a collaborative intelligent tool capable of interacting and provide real-time support to individuals and teams [5]. Still, to determine the integration value, it is essential to consider how AI can be intercepted and utilised throughout all stages of the design process. Playing a pivotal role throughout these stages, recent research has looked at the how AI can be employed at different stages to support designers with both creative generation, analysing support and optimising of design data to conceptualise and refine proposals [6]. Building on the notion presented in [7], the concern that incorporating AI might limit creative and analytical challenges serves as an important ethical consideration. To address such concerns, design educators must carefully evaluate both the efficacy and capabilities of AI tools when designing future learning scenarios. Purposeful integration of AI into design education syllabuses should not only support creativity but also encourage critical reflection, ensuring that these technologies enhance rather than constrain the learning experience. Several recent studies have reported on the use of generative AI as a foundational element in the development of design

proposals [2, 8, 9]. Considering how recent research underscores the co-creative potential of AI during the initial stages of idea generation for visual and conceptual sketches [10], this paper explores how AI can enhance design creativity and how this can be facilitated in condensed learning format. Doing so this research connects to a stream of research that has deepened the early phase innovation potential of AI in recent time. The use of LLM has been studied earlier concerning its suitability for ideation if humans can ensure key decisions, use of iterative feedback loops and prompting for quickly gather alternative considerations [11]. Although this research focuses on design creativity at the early ideation level, the inspirational elements it introduces remain compelling and warrant further exploration and demonstration in practice.

The purpose of this study is to explore how different ideation methods influence the generation and development of conceptual ideas among engineering design students. This study pursues, like a similar recent study [9], how ideation using generative AI can impact engineering design students. However, while their study targeted concepts using LLM in combination with a structured idea generation technique called 6-3-5, a method that also is known as brainwriting, which uses written text as cognitive building blocks to further build upon [12]. This study approached collaborative ideation. The research is guided by the following question: How can AI enhance the early-phase ideation process in design projects?

2 METHODOLOGY

22 Engineering design students undertaking their final year was engaged in the exercise and as part of their Advanced Product Development project course covering 15 ECTS. The paper is concentrated to actions taken through an ideation bootcamp three weeks into their projects. The ideation bootcamp was targeted as an experimental approach where traditional a brainwriting exercise was first conducted, which thereafter was input for transformative AI interpretation using Copilot (text and images) and Vizcom.ai (images). Total time was total 2h 30min. Participants were already divided into project teams with three to five students in each. In total, seven different project teams with diverse thematical challenges, ranging from the health sector (e.g. Osteoarthritis support and Oxygen assistance) to manufacturing industry (e.g. Lego injection moulding and 3D printing setup). Copilot was employed to generate a conceptualised description of the externalised ideas, but also a corresponding image or images. The refined text was then used as a prompt for to generate a visual concept proposal using Vizcom.ai. Each step was timed and lasted 15 min including instructions on the first step, LLM prompting went quicker. In this sequential format, the idea was to allow for a playful approach among the teams once they reached the visualisation step. The guided steps provided each phase to be addressed in order and repeated as needed. Notes were taken and afterwards students indicated that refined versions of the written Brainwriting insights and LLM text were further finetuned, providing more in-depth information in the explanation of the visualised ideas being generated. In-between all three steps, follow-up guiding conversations with each group provided a progress review so that all were aligned with project objectives. The purpose for this was to ensure that the participants could properly access the accounts needed (Vizcom.ai required a registered user account). The ideation bootcamp was closed with a wish and like reflection analysis where all teams got a chance to share their insights (orally, and individually on post-it notes).

The analysis was conducted by sorting out critical aspects for evaluating the ideation methods, idea generation (format), time efficiency, concept complexity, information provided, feedback and suggestions, overall perception, suitability for projects, method value, and challenges. These were deliberately chosen to align with the paper's aim of exploring how generative AI tools can be integrated into the early phases of complex engineering design education. These dimensions reflect critical pedagogical and practical considerations towards efficiency and depth of early conceptual development where the richness of information and feedback generated, and the perceived value and applicability of each method is contrasted in real-world design contexts. By comparing traditional brainwriting with AI-supported tools such as Copilot and Vizcom, the study captures a nuanced understanding of how human and machine intelligence can complement each other. The inclusion of these aspects ensures greater transparency towards a comprehensive and balanced evaluation, highlighting both the opportunities and limitations of each approach. Ultimately, this supports the argument that blending traditional and AI-driven methods fosters a more dynamic, iterative, and inclusive design learning environment. After each team had presented their outcomes, their reflections and value considerations regarding the role of AI in the creative phase were revisited towards the conclusion of the full project course. This was facilitated

through a teacher-led review, which involved a comparative analysis between the ideas generated during the ideation bootcamp and the final project outputs. This retrospective evaluation enabled a deeper understanding of the longitudinal impact of the early AI-supported ideation activities on the students' design trajectories and outcomes, offering insights into the integration of AI within design education.

3 FINDINGS

In this section, student responses are presented on aspects that they valued and perceived contributed or not benefitting their ideation process. Brainwriting were new to most and presented a introduced a novel collaborative method to collaboratively drive creative insights forward. Copilot did not provide any significant insights, but it offered a clear and precise description of what the groups aimed to achieve. Vizcom provided new visual leads that had not previously been considered. Given that one project had a project about implementing extended reality for the purpose of farmers in agriculture extract from their prompts (Table 1) addressed how they could further engage with later visual versions.

Table 1. Examples of Copilot prompts

1.	Develop a simple VR environment that replicates a farm setting.
2.	Ensure the environment enables users to interact with DeLaval milking robots.
3.	Implement features that simulate learning activities, such as operating and maintaining the milking robots
4.	How can AR help visualise real-time data from the farm?

Utilising the interactive way to display real-time data, such as livestock health, equipment status, and environmental conditions augmented reality was also considered to improve operational efficiency, and management of daily practices at the farm. The concept of monitoring livestock through data collection led to the development of an application (Vizcom) capable of rapidly identifying anomalies and signs of illness in cattle, thereby enhancing overall farm management. Figure 1 shows examples of visualised outputs from both Copilot (left) and refined versions produced in Vizcom (right).

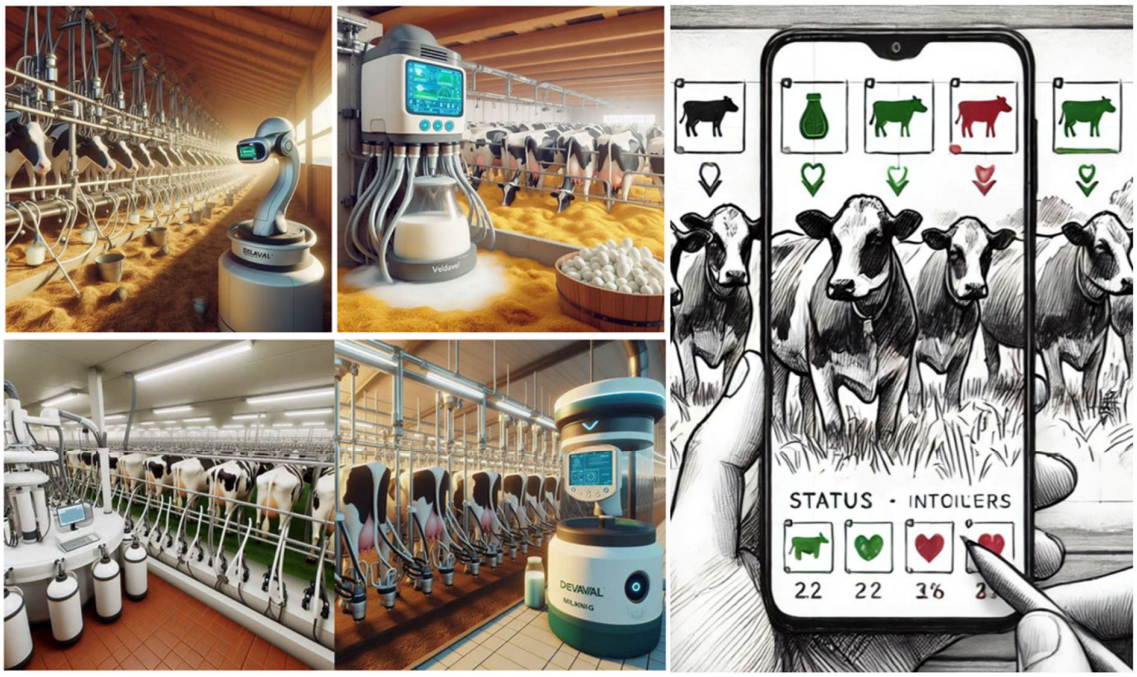

Figure 1. Visual prompts using Copilot (left) and Vizcom.ai (right)

Both students involved in the project framed in Table 1 and exemplified in Figure 1 found this exercise, quote; "perceived as effective by participants", as it allowed for students' scope to go through a series of tools having direct impact and potential contribution to their own problem area. The use of images significantly facilitated the ideation process, and employing AI to kickstart the entire ideation phase was found to be an engaging, effective, and time-conscious way to approach creative proposals early upfront.

With the images it became possible to convey information in ways that text alone would not be able to, making the connection both intuitive and effective once prompts were more refined. Using a structured process to equip students with a better understanding of AI-powered design tools was perceived enriching as brought forward new perspectives. However, in many cases, students questioned why the AI-generated visual presentations followed a "predetermined" design. At the same time, they acknowledged this as an acceptable constraint given the program being used. As one student stated, "It was beneficial to conduct brainstorming sessions within a short timeframe, although this meant we couldn't fully develop all aspects of the ideas that emerged." Given the amount of detail and design complexity provided after the initial brainwriting exercise, another group expressed more scepticism. They stated, "Since we had a relatively narrow and predefined problem, our concept ended up being too complex to receive a satisfactory response from Copilot." According to their group, visual input did not yield any results of greater interest due to the narrow scope of their project, which was specifically related project acts as a filter, rendering any elements beyond the appropriate design elements irrelevant." In summary, Table 2 provides an overview of the clustered thematic aspects by the different methods, structured according to the notes and expressions gathered from student reflections during the follow-up feedback process.

Table 2. Ideation Bootcamp Aspects and Methods

Aspect	Brainwriting Method (Traditional pen & paper)	LLM Prompt (Copilot)	Visualised Ideas (Vizcom.ai & Copilot*)
Idea Generation	Good ideas built upon by group members	Clear descriptions, no major new insights	New insights and ideas not previously considered
Time Efficiency	Short time for brainstorming, limited detail	Efficient but complex concepts were challenging	Visualisations provided new perspectives
Concept Complexity	Suitable for simple concepts	Struggled with complex concepts	Better for design than construction
Information Provided	N/A	Detailed pros and cons, alternative suggestions	Visual representation of conceptual ideas
Feedback and Suggestions	N/A	Additional thoughts and valuable feedback	Visual feedback on specific elements and on concept level
Overall Perception	Effective for initial ideation	Useful for refining ideas	Enhanced visual understanding
Suitability for Projects	Better for projects needing deep exploration	Suitable for refining existing ideas	Better for design-focused projects
Method Value	Promoted good brainstorming	Provided valuable factual insights	Offered new visual perspectives
Challenges	Limited by time	Complex concepts were difficult to address	Visualisation complexity

**Copilot provided additional visualised design proposals, incorporated to the discussion and refinement as highlighted by one project team.*

According to student reflections, one student points out; "the integration of AI tools like Copilot and Vizcom.ai supported us to process the iterative ideation process, adding new perspectives, and helped refine ideas and early concepts." Feedback indicates that adding AI tools is positive, as it broadens the early-phase design process. This enhancement is appreciated, as it motivates and captures tools and tasks in a relevant form, extending the existing learning environment. It provides "an easy-going form for articulating and developing ideas." Still, students were not all positive, as an exercise it may be fun to test and experiment with emerging tools, but you soon realise that to provide value it needs to generate something of relevance. Sceptic voices were also raised "little direct value," "difficult to match the constraints of current practices, no limitations seem to exist." The exercise reflections indicated that the documentation process throughout the exercise was not problematic at all. In addition to the used ideation exercises, some students noted that among all the different ideation methods used, a few others would also be incorporated to support the systematic approach, while at the same time documenting ideas. Although some students had prior experience with large language models (LLMs) like Copilot, the bootcamp's unique setup, which allowed students to engage in rapid idea evolution and visualisation,

was entirely new. Traditional brainstorming, mind-mapping, and different design thinking exercises were considered a comfortable way to further add to the collected insights. Students did not hesitate to prompt for alternatives once they had tested the different tools, which for some participants enabled their perceived best fit to be determined.

4 DISCUSSION

Findings underscore the transformative potential of AI in design education, not only for adding new perspectives but to be a process enabler, supporting both creativity and workflow. Fostering collaborative idea generation, brainwriting provided project specific insights that was processed as a prompt for Copilot and with Vizcom.ai providing detailed feedback and visual insights. The findings suggest that integrating AI-powered tools into human-centred product-service system design education is not just a trend but a powerful tool worth the time it takes to integrate to make early phase ideation both more fun and diverse. As a user, you are provided by prompted suggestions that can influence cognitive processing at various stages and depths. This structured support fosters a more efficient, creative, and iterative design process, enabling students to harness the power of AI in developing innovative solutions. The bootcamp demonstrated that integrating traditional methods with AI tools can be both fun and enriching while fostering a dynamic learning environment.

This research identifies a strong connection to similar attempts aimed at testing and evaluating the degree of novelty generated through ideation measures [2], [8], that explicitly highlight the advantages of influencing and building upon each other's expressions in a systematic manner [9]. Like the contrasts explained in the procedure to use this technique [12], the self-governing advantage of teams organically controlling their progression enabled self-control, freedom and possibility to steer cognitive mapping activities away from out-of-scope ideas. In comparing human creative skills with the conceptualisation capacity of AI's, an LLM tool has been used to evaluate the value of human creativity versus artificial computer-generated outputs. Based on a prototyping bootcamp research findings and subsequent recommendations for implementing an LLM in the design process [11], similarities to this study are striking as the stepwise ideation bootcamp mirrors several of the concerns. However, although the actual ideas were never measured based on perceived performance, both the ideation bootcamp and the prototyping counterpart emphasise the involvement of a human validation step to ensure the prompts' accuracy in generating useful concepts.

The research aimed to determine how can AI enhance the early-phase ideation process in design projects. This was achieved by testing a synergistic design approach, where ideas, much like in brainwriting, are continuously fed into subsequent iterations. To ensure the effectiveness of such a setup, it is essential to have a defined scope or predetermined objective. Rather than constraining creativity, this structure helped prevent ideas from diverging excessively, ensuring they remained relevant and contributory to the project. While AI tools introduced unpredictability, often producing outputs that were chaotic or overly imaginative, they also mirrored the exploratory nature of a curious learner, eager to support the user's intent. This unpredictability, while sometimes misaligned with design goals, introduced a valuable layer of creative provocation, resembling a dialogue with an eager, inquisitive child who enthusiastically absorbs and reflects everything it can to satisfy the user's intent. Although few tangible outputs from the bootcamp could be directly traced through the 20-week student projects, the session proved to be an enriching learning experience. It offered students motivation, enjoyment, and a fresh perspective on integrating AI into their design practice. Ultimately, this fusion of traditional ideation techniques with AI tools not only demonstrated the potential of synergistic design but also opened new avenues for educators to stimulate creativity and critical reflection in early-phase ideation.

5 CONCLUSIONS

The insights gained from the Ideation Bootcamp affirm the effectiveness of combining traditional brainwriting with AI tools in a structured, sequential manner. This hybrid approach not only facilitated the generation of novel ideas but also enriched the iterative design process, offering students a dynamic and engaging learning experience. While some visual outputs from the AI tools were overly imaginative and leaned more towards playful exploration than actionable design feedback, they nonetheless contributed to a stimulating creative environment. Importantly, the session underscored the significance of ethical considerations in shaping design prompts and interactions with AI. The true value of such an initiative lies not solely in the novelty of the tools themselves, but in their capacity to provoke reflection, and by encouraging students to critically examine the "why" and "how" behind AI's influence on their

design thinking. The integration of these diverse methods introduced a new dimension to the design process, significantly enhancing students' ability to approach complex challenges with innovative strategies. Even for those with prior exposure to large language models like Copilot, the opportunity to rapidly evolve and visualise ideas in this context was entirely new. Human-to-human interaction remained a valued component, with the structured guidance further enriching the learning experience. Ultimately, the comprehensive and iterative process opens up new opportunities for design educators to foster creativity in early-phase ideation by blending traditional methods with emerging AI technologies.

6 RECOMMENDATIONS

Based on the findings, an overall suggestion would be for other design educators and researchers to continue implementing AI tools for exploring its impact on student learnings and impact on end results. A systematic, stepwise process that integrates traditional methods with AI-enabled tools not only provide rapid feedback but, more importantly, offers a valuable opportunity for reflection. It encourages students to consider their role in the process and to explore the extent to which diversity and complexity can be embedded to elevate final solutions. A practical approach would be to incorporate a series of seminars or reflective sessions that further interpret and contextualise these experiences.

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REFERENCES

[1] Littman M. L., Ajunwa I., Berger G., Boutilier C., Currie M., Doshi-Velez F., Hadfield G., Horowitz M. C., Isbell C., Kitano H., Levy K., Lyons T., Mitchell M., Shah J., Sloman S., Vallor S. and Walsh T. *Gathering Strength, Gathering Storms: The One Hundred Year Study on Artificial Intelligence (AI100) 2021 Study Panel Report.* Stanford University, Stanford, CA, 2021, September. Accessed: September 19, 2024. http://ai100.stanford.edu/2021-report.

[2] Zhou C., Zhang X. and Yu C. How does AI promote design iteration? The optimal time to integrate AI into the design process. *Journal of Engineering Design*, 2023: 1-28.

[3] Berglund A. Design thinking: catalysing change in the educational ecosystem–a framework for future challenges. *Design Science*, 2024: 10, e34. https://doi.org/10.1017/dsj.2024.39.

[4] Kaur K. Role of artificial intelligence in education: Peninsula college central Malaysia. *International Journal of Academic Research in Progressive Education and Development*, 2021, 10(2), 890–898. https://doi.org/10.6007/IJARPED/v10-i2/10573.

[5] Ouyang F. and Jiao P. Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*, 2021, 2: 100020.

[6] Khanolkar P. M., Vrolijk A. and Olechowski A. Mapping artificial intelligence-based methods to engineering design stages: a focused literature review. *AI EDAM*, 2023*,* 37, e25. https://doi.org/10.1017/S0890060423000203.

[7] Meron Y. and Araci Y. T. Artificial intelligence in design education: evaluating ChatGPT as a virtual colleague for post-graduate course development. *Design Science*, 2023, 9, e30.

[8] Ge P. and Fan F. A Systematic Review of the Role of AI Artificial Intelligence in Design Education. In *DS 131: Proceedings of the International Conference on Engineering and Product Design Education (E&PDE),* 2024*,* (pp. 103-108).

[9] Hamilton V., Brisco R. and Grierson H. How can AI support the creation of novel ideas in product design. In DS 131: Proceedings of the International Conference on Engineering and Product Design Education (E&PDE), 2024, (pp. 133-138).

[10] Wilson C. *Brainstorming and beyond: a user-centred design method*, 2023, Newnes.

[11] Kim J., Maher M. L. and Siddiqui S. Collaborative Ideation Partner: Design Ideation in Human-AI Co-creativity. In *CHIRA*, 2021, (pp. 123-130).

[12] Ege D. N., Øvrebø H. H., Stubberud V., Berg M. F., Elverum C., Steinert M. and Vestad H. ChatGPT as an inventor: Eliciting the strengths and weaknesses of current large language models against humans in engineering design. *AI EDAM*, 2025, 39, e6.