

EXPLORING THE IMPACT OF GENERATIVE AI ON CONCEPT GENERATION, IDEATION, AND DESIGN METHODOLOGY: IN PRODUCT DESIGN EDUCATION.

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ABSTRACT

This paper presents an investigation into the utilisation of generative artificial intelligence (AI) by product design students in the concept generation, ideation, and design methodology of their final year major project. With AI's growing presence in the design field, its impact on the education of future designers requires investigation. This research aims to highlight the advantages and disadvantages associated with incorporating certain generative AI tools into the curricula of product design students. The study involves an in-depth analysis of how generative AI could be integrated into the design education process. It explores the extent to which AI-driven tools are employed by students to generate, refine, and iterate design concepts, and how it impacts their design methodology processes. By appraising and analysing the outcomes from AI creative design workshops and conducting surveys with final year product design students, this research sets out to determine the practical applications of generative AI in our future designers. By investigating the advantages and disadvantages, it equips educators and students with valuable knowledge to harness the full potential of AI in their design journeys. This paper contributes to the ongoing conversation on AI's role in design education, paving the way for informed pedagogical decisions and the education of future designers who can leverage AI as a powerful creative tool.

Keywords: Generative AI, Design Process, Design Methods, Ideation, Concept Generation.

1 INTRODUCTION

More than thirty UK universities deliver courses in the field of product design as of 2024 [1]. Over the years, these institutions have adopted new technologies to keep up with contemporary industry techniques and expectations. This includes solid and surface modelling CAD (Computer Aided Design) in the eighties, CAD simulation in the nineties, and more recently, 3D printing technologies. The advent of AI creative tools poses an inevitable area of special interest, worthy of consideration for inclusion within undergraduate Product Design courses. In 2002, an E&PDE paper [2] was presented, that discussed research being undertaken at the time into the potential role(s) of artificial intelligence (AI) as a creative capability within CAD software. The paper described how it could be possible for AI to produce highly detailed colour and form concepts more quickly than was humanly possible. Twenty years later, this prospect became a reality. Creative applications have swiftly become available, with software such as ChatGPT (Open AI Inc, San Francisco) and Midjourney (Midjourney Inc, San Francisco) demonstrating significant capabilities in the arts [3,4]. These software tools can create high quality, completed works of a level of detail that is both awe inspiring and startling when compared to that of human capabilities in a similar timeframe. The potential design applications are immediately apparent. A lot of a designer's time is used exploring possibilities, comparing alternatives, and breaking new ground. The iterative nature of designing new products can be labour intensive and resultantly carries significant financial risk [5]. As predicted in 2002, by exploiting the power of AI, we can, in principle at least, reduce this time to our advantage and ultimately deliver outputs faster and at a lower cost.

This research explores the utilisation of generative AI by final year product design students during their major project. While AI's influence in design has been increasingly recognised, its specific application

within the educational context of being part of the concept generation phase of final year projects represents an emerging frontier. As the design field evolves in response to technological advancements, this research offers an initial investigation into the suitability, strengths, and weakness of contemporary AI technologies for the purposes of concept generation within the product design process. The results of this research will allow educators to gain valuable insights into how to effectively incorporate AI into their teaching methods, enhancing the educational experience and preparing students for a technologically driven design industry.

2 RESEARCH METHOD

The rate of development of AI software has meant that the capabilities of the tools on offer have advanced significantly in a short period of time. Hence, a future market leader for Product Design applications seemed uncertain at the time of this research. Of those widely available in 2023, Midjourney was considered one of the most capable and frequently used for the purposes of creative visualisation, particularly when generating images solely from verbal descriptors. It also offered some enhanced capabilities, such as the use of control parameters (such as ‘chaos’ and ‘weird’, etc.) and syntax rules (such as ‘multi-prompts’) to allow the breadth of results to be fine-tuned. It was therefore chosen as a means of appraising the general suitability of generative AI tools for designers at the present time.

2.1 Methodology

To determine whether Midjourney might be a useful tool for design students at the early stages of the product design process, a study was devised that could be inserted straight into students’ projects with minimal disruption to existing workflow. To this end, a group of Final Year undergraduate product design students was invited to generate preliminary design possibilities based on their final year project proposals. This way, they would be able to compare the results from their interaction with the software, with any early ideas that they might have conceived of their own. The study was split into two phases. Phase one was scheduled shortly after the students had submitted their final year project proposals. This phase was intended to determine the value of the software in providing the students with initial inspiration before they had spent time developing concepts of their own. Phase two was scheduled a few weeks later, giving the students time to reflect on the results of phase one and to develop their own ideas further, either in isolation or in combination with the results of phase one. Phase two was intended to explore the benefits of using the students’ own sketches as prompts for further development within the AI software.

In the first phase it was anticipated that the students would use the software to ideate a broad range of initial ideas using verbal prompts only, when they had relatively little understanding of the design problem they were seeking to solve. The students were encouraged to identify relevant semantic phrases to describe their design aims in verbal form. The capabilities of Midjourney at the time of this study, enabled users to input their intentions using verbal phrases and images to prompt the AI software. Of particular interest, was the students’ ability to control and refine ideas verbally to meet their design objectives, and their subsequent perceptions of the output results. The design students were given a brief overview of how to use verbal prompts and associated syntax. They were then given up to one hour to create as many ideas as they could, based on their individual design project briefs. During that time, they were provided with 1:1 tutor support on how to exploit features offered by the software to enhance its capabilities and to produce a wider or narrower field of results. At the end of this session, the students were asked to provide feedback on their experience via a 5-point Likert scale questionnaire.

In the second phase, the students were invited to use their own initial design sketches as image prompts. They were shown how to upload sketches, how to create image prompts and how to combine them with other images as well as verbal prompts to provide the software with contextual information to help refine the results (Figure 1). The ability of the software to produce meaningful results from what the students provided was of particular interest. Again, the students were given one hour to experiment with the software, during which they were provided with 1:1 technical support should they need it. At the end of the hour, they were asked to complete a follow-up questionnaire, to capture their opinions and experiences.

3 RESULTS AND DISCUSSION

3.1 Application/Usability

Phase 1 of the study commenced shortly after the approval of the students' final year design project proposals. It was anticipated that these students would be open minded to a broad range of design possibilities. However, it soon became evident that they had yet to develop a deep contextual understanding of their design problems, leading to some being frustrated at being unable to express their objectives effectively. Others found that Midjourney's tendency to prioritise broader scenes over the specific product design posed a challenge. It was apparent this was not due to the text prompts alone, but also the contextual information being provided and how Midjourney interprets that information and produces results. Midjourney creates groups of four results for every prompt. Using the same prompt never produces the same results twice, but rather, somewhat similar results conforming to the parameters set. The level of similarity and conformity could also be adjusted further, using the relevant control parameter (i.e. 'chaos'). However, few students entered the same prompts repeatedly, preferring instead to rephrase their prompts to try to refine the subsequent outputs.

Phase 2 took place three weeks later, giving the students time to work on their projects during the interim. This time the students were invited to bring sketches of their own that could be used as image prompts for Midjourney. The sketches provided by the students varied greatly in terms of detail, colour, and quality of line. However, the AI software seemed capable of interpreting their intentions surprisingly accurately, especially when verbal prompts were provided for additional context. Using more than one image prompt in combination with detailed verbal descriptors yielded some of the most promising results, due to the designer students' ability to home in on a particular intention. However, the degree of emphasis placed on a particular product's design was not always predictable or easily controlled, as illustrated in Figure 1 where the subject (lamp) is shown as part of the scene, rather than the focus of the scene.

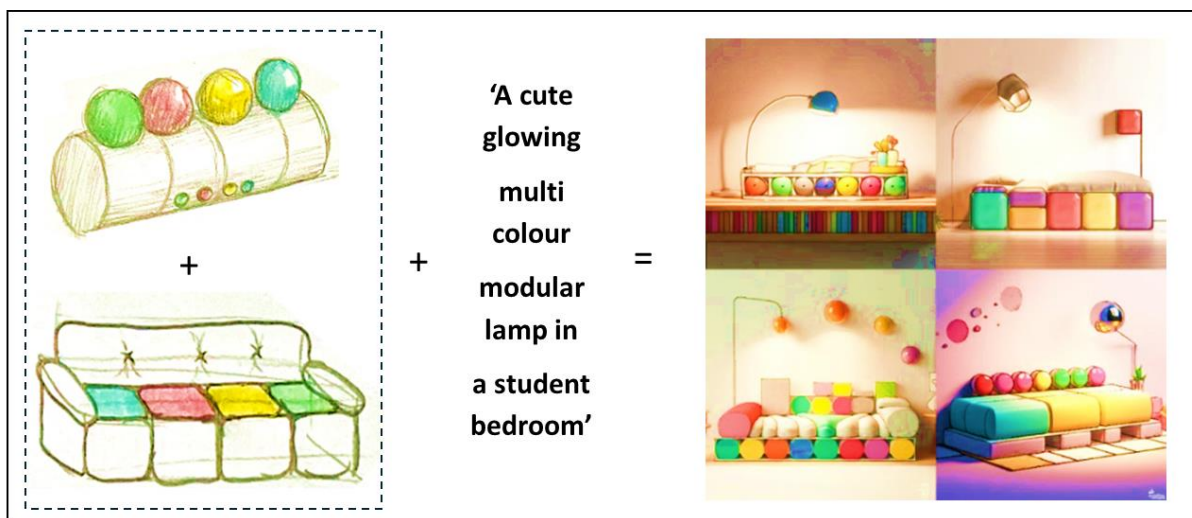


Figure 1. Example result of combining image and verbal prompts in Midjourney (courtesy of student)

3.2 Verbal Prompts

26 students took part in phase 1 during which verbal prompts were used by to communicate design intentions using Midjourney. These prompts consisted of written descriptions or commands, which served as an input for Midjourney to generate visual outputs. The findings from this research focus on 3 main areas from the use of image prompts within the concept generation phase of the product design process.

3.2.1: Conceptual Inspiration

Questions were posed to understand the conceptual inspiration that Midjourney could offer during the concept development stage within the students' product design process. The findings aimed to

understand how the AI-generated concepts sparked creativity and innovation and determine if the students believed Midjourney could produce innovative and original ideas. The students were also prompted to consider if the visualisation of the AI outputs were inspirational and if they offered an exploration into the design problem and potential solutions.

96% of participants agreed or strongly agreed that the AI concepts provided them with creative inspiration and were pleasantly surprising. This indicates that the students found Midjourney's outputs to be genuinely inspiring in terms of generating creative ideas, and that the outputs were perceived as pleasantly surprising by majority of the students. 92% of participants agreed or strongly agreed the way the AI concepts were visualised was inspirational. 77% of participants agreed or strongly agreed that the AI design concepts were unexpected. This suggests that while the AI outputs were viewed as inspiring and visually appealing, they may not have consistently pushed the boundaries of expectation of the students or produced innovative concepts.

Students were also asked to consider what they believe Midjourney's main strengths in aiding their concept development could be. Exploring a broad range of useful design alternatives quickly emerged as its main strength with 92% of participants stating this. Visualisation of potential design solutions was stated as the second main strength with 88% of participants stating this. However, Midjourney's ability to inspire innovative approaches to design challenges was ranked comparatively low, with 77% of participants stating this as a strength. These results highlight both strengths and relative weaknesses in using Midjourney with regards to conceptual inspiration within the concept development stage of the product design process. Whilst the outputs were mainly seen as inspiring and visually appealing, more unexpected and innovative concepts would help to stimulate greater creativity amongst the students.

3.2.2: Depth and Completeness

Questions were directed towards the students to assess the depth and completeness of their Midjourney outputs to understand if they considered them to be functionally suitable, relevant, and applicable for the intended application (as outlined in their project proposals). Questions regarding the completeness of the AI outputs sought to determine if the concepts presented a holistic and well-rounded perspective on the design problem. The students were asked to consider if the AI outputs explored design possibilities in depth, indicating the system's ability to perform exploration and ideation. The students were also asked to consider how Midjourney created outputs with the avoidance of preconceived design solutions, to evaluate its ability to generate innovative and unexpected concepts, free from conventional biases.

The responses indicate a generally positive perception of the functional suitability, completeness, and level of depth of the Midjourney concepts; however, this is far from conclusive. 58% of students agreed or strongly agreed that the AI design concepts were functionally suitable for the intended application, yet 15% disagreed. 69% agreed or strongly agreed that the outputs seemed generally complete, but 8% disagreed. 81% agreed or strongly agreed that the outputs explored design possibilities in depth, 4% disagreed. And 73% agreed or strongly agreed that Midjourney effectively avoided preconceived design solutions, however 8% disagreed or strongly disagreed. These findings suggest that the majority of students found the AI outputs to be comprehensive and suitable for supporting their concept development through depth and completeness of outputs. However, the significant presence of neutral, disagree, and strongly disagree responses highlights individuality of user experiences and perspectives when evaluating the effectiveness of using AI tools within the concept development phase.

3.2.3: Interpreting Intentions

Questions were presented to understand how effectively Midjourney outputs interpreted the students' intentions using their verbal prompts. By understanding if it was easy for them to express their desired outcomes via verbal prompts, the research aimed to analyse Midjourney's ability to understand and translate their intentions and instructions accurately. This also allowed an insight into the synergy between the user and AI system, as well as the degree to which Midjourney effectively captured and understood the students' intentions during the creative process.

The results show a mixed perception among students regarding the ease of expressing their specific design objectives using verbal prompts. Only 9% of students agreed or strongly agreed that it was easy

to express what they wanted to create, whilst 38% disagreed or strongly disagreed. Opinions were also divided regarding whether Midjourney interpreted their specific intentions as expected, with 48% agreeing or strongly agreeing and 32% disagreeing or strongly disagreeing. These findings suggest either a degree of inconsistency in Midjourney's ability to accurately interpret and translate user intentions from verbal prompts, or a varying level of ability amongst the students to use verbal prompts to articulate their intentions.

3.3 Image Prompts

Image prompts were used by 12 students as an input method for generating visual outputs in conjunction with verbal prompts. Image prompts provided the students with a more concrete and visually intuitive input method compared to the use of verbal prompts alone. The findings from this research focus on 2 main areas from the use of image prompts within the concept generation phase of the product design process, and how the students' perception of the results of using image prompts varied from those of using just verbal prompts.

3.3.1: Depth and Completeness

To assess the effectiveness of visual input in producing outputs that had practical relevance and applicability, students were asked to establish if they were able to explore initial concepts in greater depth using image prompts, if they believed the outputs were more functionally suitable, and if the outcomes were more complete. This gave insight into Midjourney's ability to provide holistic and well-rounded design suggestions based on visual inputs, compared to verbal inputs.

The findings demonstrate a generally positive opinion of the depth and completeness of the outputs generated with image prompts. 75% of students agreed or strongly agreed that they were able to explore their initial concepts in greater depth using image prompts, suggesting that sketches generally facilitated a more comprehensive exploration of their design ideas. However, opinions were divided regarding the functional suitability of the AI design concepts produced with image prompts, with 42% of students disagreeing that the AI concepts were functionally suitable. Similarly, 67% agreed or strongly agreed that the AI design concepts seemed more complete when generated with image prompts, 25% disagreed or strongly disagreed. These findings suggest that while image prompts may provide depth and completeness within their concept generation, improvements can be made to ensure the generated concepts are seen as functionally suitable by students. Further investigation into the factors influencing these perceptions, such as the quality of the original sketches from students and the resemblance of the AI outputs, could inform the use of image prompts within Midjourney for concept generation in product design.

3.3.1: Interpreting Intentions

To investigate the ease and efficacy of expressing specific design intentions via image prompts students were asked how the outputs produced using this method compared to those generated using verbal prompts. This aimed to assess the clarity and effectiveness of visual communication versus verbal communication. The students were asked to consider whether the results produced using image prompts were more aligned with their expectations, indicating Midjourney's ability to accurately interpret visual cues. Additionally, questions about the productivity and value of using image prompts aimed to evaluate the effectiveness of visual input as a tool for concept development within the design process.

82% of students agreed or strongly agreed that it was easier to express specifically what they wanted to create using image prompts, indicating that visual prompts aided in articulating their design objectives effectively. 67% of students agreed or strongly agreed that the results produced using image prompts were more as they had expected than in phase one, suggesting that Midjourney was somewhat successful in translating their sketches into concepts. A significant majority, 90%, of students agreed or strongly agreed that the use of image prompts was a productive and worthwhile design method, highlighting the perceived value and effectiveness of incorporating original sketches in conjunction with Midjourney for concept generation in product design. These findings highlight the importance of visual communication in facilitating the students design intentions whilst using AI within their concept generation.

4 CONCLUSION

The findings from this research provide insights into the effectiveness of utilising Midjourney within concept development and demonstrate a strong positive reception to conceptual inspiration. The students believed their concepts to be creatively inspiring, visually pleasing, and enabling them to overcome creative blocks. However, the depth and completeness of the outputs provided mixed responses, with several students expressing neutral or negative opinions, and remarking they wanted more emphasis placed on the product rather than the user in the output. The results regarding Midjourney's ability to interpret the students' intentions through verbal prompts are inconclusive, suggesting varying levels of success in either Midjourney's ability to capture the students' intentions accurately, or the students' ability to precisely articulate their ideas verbally. It was evident that Midjourney could generate diverse and rapidly changing outputs. However, as students attempted to develop their verbal prompts further, they tended to find that superficial details would be added rather than the refinements they were anticipating. Furthermore, the software did not engage them actively as creative participants and it was not possible for them to modify ideas or converge them to an optimum point. Judging by the results of the follow-up questionnaire, this was apparently seen as a significant limitation of the software (at this time).

The research highlights a significant difference in students' perceptions in Midjourney's ability to interpret their intentions effectively when using image prompts compared to verbal prompts. Students reported finding it easier to express their design intentions and that results aligned more with their expectations when using image prompts. This suggests that visual communication is a more effective way than verbal communication for design students to convey their design ideas and intentions. Given that design students are often more visually orientated, their preference for using image prompts is understandable. This positive response to using image prompts demonstrates the value of incorporating the use of visual AI tools within the design process, as it facilitates a creative and productive interaction between the designer and AI tools. This interaction between human designer and AI tools may be crucial, as designers often need to be immersed in the creative problem-solving activity in order to be effective and invested in the outcome. As new AI tools come to market with enhanced capabilities, this ability for designers to exploit them so that concepts can be fine-tuned towards convergent, meaningful solutions, may be a critical characteristic for success. The breadth and types of generative AI tools on offer is expanding quickly. Other platforms such as Vizcom (Vizcom Technologies Inc, Hanover), DALL-E (Open AI Inc, San Francisco), and Adobe Firefly (Adobe Inc, California), offer different and rapidly emerging capabilities, warranting further research into how and where they could be implemented into the product design curriculum most effectively.

REFERENCES

- [1] The Guardian, 2023, *Best UK universities for product design – league table*, The Guardian, Available at: <https://www.theguardian.com/education/ng-interactive/2022/sep/24/best-uk-universities-for-product-design-league-table>, [Accessed on 2024, 20 February].
- [2] Dyer, B., Eves, B., Griffiths, W., Lefley, M., Reynolds, T., 2002, "Design Semiotics – 'arty' – ficial intelligence CAD" in: MAC. EVATT, EK. BRODHURST. *Proceedings of the SEED 24th Annual Design Conference*, Coventry University, Coventry, UK: Professional Engineering Publishing Ltd, 225-226.
- [3] Anderson, S. 2024. ChatGPT Helped Write This Award-Winning Japanese Novel. *Smithsonian Magazine*. Available at: <https://www.smithsonianmag.com/smart-news/this-award-winning-japanese-novel-was-written-partly-by-chatgpt-180983641/> [Accessed on 2024, 14 February].
- [4] Roose, K. 2022. *An A.I.-Generated Picture Won an Art Prize*. Artists Aren't Happy. *The New York Times*, 02/11/2022
- [5] Hong, M., Hakimi, S., Chen, Y., Toyoda, H., Wu, C., & Klenk, M. (2023). Generative AI for Product Design: Getting the Right Design and the Design Right. *In CHI '23: ACM CHI Conference on Human Factors in Computing Systems*, April 23-28, 2023, Hamburg, Germany. ACM. New York. NY. USA.