26TH INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
5-6 SEPTEMBER 2024, ASTON UNIVERSITY, BIRMINGHAM, UNITED KINGDOM

CO-DESIGN AND ARTIFICIAL INTELLIGENCE: A METHOD TO EMPOWER END-USERS IN VISUAL COMMUNICATION

Addie PAYNE MORGAN[1], **Grace KILBOURN BARBER**[1], **and Bryan F. HOWELL**[2]
[1]Professional, United States of America
[2]Brigham Young University, United States of America

ABSTRACT
Co-design brings designers, end-users, researchers, and other pertinent stakeholders together to forge meaningful design solutions. It dismantles traditional barriers between professional designers and end-users by fostering collaborative, participatory design development processes. This paper explores using an AI visualisation tool, Vizcom, in a co-design workshop. The tool helps participants without visualisation skills to convert their rough sketches into refined visual representations. Thirty-six undergraduate students from Brigham Young University across ten disciplines participated in the study. Participants were introduced to the principles of co-design and the functionalities of the Vizcom, including how to create accounts, craft effective textual prompts for AI, and adjust the drawing influence parameter to optimise the visualisation of their ideas. Participants worked in pairs, designated as "users" and "professionals." Prompted to reflect on their campus lunch food heating experiences, users shared insights with professionals who conducted interviews to pinpoint specific problems. Following this, professionals and users brainstormed solutions together. The users then sketched the proposed solutions, guided by the insights and ideas discussed during their collaborative session. After completing their sketches, they used their mobile phones to upload their sketches and detailed prompts into Vizcom, generating visual representations of their concept.
The study collected feedback from both professional and user roles through separate surveys, assessing the effectiveness of the AI in capturing and enhancing their conceptual solutions. The findings suggest new avenues for co-creation in product design, emphasising the potential of AI tools to bridge the gap between rudimentary sketches and sophisticated visual outputs.

Keywords: Collaborative product development methods, Vizcom research, product visualisation, sketching with AI

1 INTRODUCTION
Co-design focuses on dismantling the traditional barriers between professional designers and end-users by fostering collaborative, participatory design development processes [1]. The goal is to democratise the design process, ensuring that end-user perspectives shape the outcomes of a design process [2]. In turn, this practice promotes an inclusive design environment, focusing on participants' collective creativity and insights, emphasising contributions from those without formal design training in product development [3]. A prominent co-design researcher, Liz Sanders, has significantly contributed to promoting participatory design and co-design principles. Her methodology transforms users from passive informants to active co-creators through accessible and engaging tools such as drawing, modelling, and manipulating tangible materials. These tools encourage participation and serve as concrete reference points that aid in discussions, guide direction-setting, and support decision-making processes [1].
Designers are trained in sketching as a visualisation method essential to the design process [4]. Recent developments in artificial intelligence (AI) tools in visual communication, particularly in design sketching, introduce new possibilities for co-design methods by providing untrained sketchers with a tool to help them visualise their ideas [5]. These AI tools serve as intermediaries, enabling individuals who may not possess formal design or visualisation skills to communicate their concepts effectively. AI

enables rapid generative visualisation of a participant's abstract ideas into coherent visual forms, thus expanding the co-design process in new ways [6].
In product design, "product visualisation" refers to various graphical representations to conceptualise and convey design concepts, solutions, and product features throughout the design process [7]. Visualisation involves techniques and media tailored to meet the needs and capabilities of individuals involved in product development, including industrial and engineering designers. These visualisations can range from basic analogue sketches to sophisticated 3D CAD models that facilitate clear and effective communication between designers and stakeholders [7]. Visualisations enable design explorations, assess feasibility, and ensure ideas are conveyed accurately to technical and non-technical audiences [8].
Incorporating sketching by users, even those without formal training in visualisation, at the early stages of the co-design process significantly enhances their engagement, allowing them to actively participate in shaping the initial design concepts [9]. This paper explores the relationship between participants with rudimentary visualisation skills and an emerging AI visualisation tool called Vizcom in a co-design workshop. Vizcom provides non-sketchers with a tool to visualise their roughly drawn ideas rapidly. We expect this will uncover new methods of co-creation activities that could evolve traditional product design processes. Our research focuses on the participants' viewpoints regarding the value of this process on collaborative concept creation and design process effectiveness.

2 METHOD

2.1 Participants

Thirty-six undergraduate students from Brigham Young University, comprising eight females and twenty-eight males, participated in the study: twelve from Industrial Design, six each from Computer Science and Mechanical Engineering, two each from Electrical and Manufacturing Engineering, four from Entrepreneurial Management, and one each from Philosophy, Machine Learning, Economics, and Information Systems. Participants received no extra credit or compensation and were free to withdraw from the study.

2.2 Procedure

2.2.1 Co-Design Process

Participants were presented with the concept and process of co-design through a short presentation. Students were put into pairs, taking the role of “professional” or “user.” While the professionals may have varied levels of visualisation training, the critical factor was that the 'users' lacked formal training in visualisation techniques.

2.2.2 Vizcom AI Sketching Guidelines

Participants were taught effective sketching practices for the AI tool to interpret. They were instructed to draw clean, bold lines, including key product features, one idea per page, fill the centre of the page, and not lay marks near the page edges. The emphasis on clarity and scale aimed to mitigate common issues associated with AI processing, such as the misinterpretation of text and poorly defined sketches.

2.2.3 Prompt Construction and Influence

Participants were introduced to the nuances of crafting textual prompts for the AI. The instruction highlighted the impact of word order on the AI's output, advising a strategic arrangement of descriptive terms to guide the AI towards the intended visual outcome. Additionally, participants were advised to adjust the drawing influence parameter (a slider tool in the software), ideally between 60-70%, to balance the authenticity of the original sketch with AI-generated enhancements. This iterative adjustment process encouraged participants to experiment with and refine the AI output.

2.2.4 Interview and Ideation

Initially, the professional conducted a comprehensive interview with their user counterpart to gather in-depth insights into the users' experiences and specific requirements regarding the prompt, "heating food on campus". The professionals were advised to use open-ended questions and probe further into brief responses from the user to acquire a deeper understanding.

2.2.5 Collaborative Sketching

Following the interviews, participants began a collaborative sketching session to solve an issue identified in the interview phase. The professionals used notes from the interviews to prompt the user while they sketched a product concept. Participants were provided paper and black markers to complete their sketches, Figure 1.

Figure 1. Selected user sketches of an on-campus food heating product concept

2.2.6 AI Integration

Participants uploaded their sketches and detailed prompts using their mobile phones to the Vizcom AI, which then used its algorithms to generate visual representations of the solutions envisioned by the users. Participants were encouraged to adjust the prompt language and influence settings iteratively until they were satisfied with Vizcom's output, Figure 2.

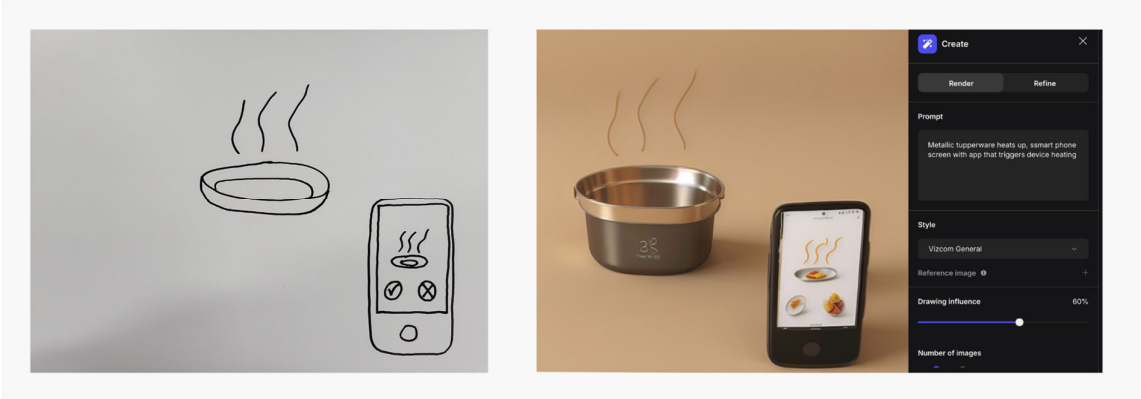

Figure 2. The left image shows the original sketch. The right image displays the Vizcom rendering of the product concept and the accompanying prompt: "Metallic Tupperware heats up, smartphone screen with app that triggers device heating"

2.2.7 Reflection and Feedback

Each team presented their rendered outputs and the original idea sketches to the class, who provided feedback on the projects. The workshop moderators also solicited input from the class regarding their experience.

2.3 Data Collection

Professional and user participants completed separate surveys, provided their interview and sketch session insights, and wrote notable observations during the AI visualisation process. Additionally, participants were asked twelve questions to assess the degree to which they believed the AI-generated visuals reflected their concepts. They used a five-point Likert scale for quantifiable measures and open-ended questions for qualitative insights.

2.4 Analysis

A mixed-methods analysis was used to assess data. Qualitative inputs such as interviews, sketches, and reflections were thematically analysed to identify perceptions and outcomes of the AI-assisted design process. Quantitative data from user feedback ratings was analysed to assess overall satisfaction with the AI-generated representations.

3 RESULTS

3.1 Analogue Sketching Effectiveness

A rating of 3.72 out of 5 indicates that participants viewed sketching as somewhat effective for visualising ideas. While sketching is generally seen as beneficial, there is variability in its perceived effectiveness across participants, and the efficacy of sketching was not uniform across all aspects of idea representation. Some participants reported that while conventional elements were captured well, the ideas' more innovative and abstract parts were not as successfully communicated. One participant pointed out that "The microwave part [was captured the best by my sketch] ... The innovative parts were not captured well by my sketch," implying that while certain conventional elements were effectively depicted, the more innovative aspects of the idea were not as successfully communicated. Further, respondents noted that sketches effectively depicted "The general shape, little features I thought of adding," and "The essence and spatial placement of entities," indicating that sketches were particularly adept at capturing basic shapes and the spatial relationships between different components of an idea. These responses underscore the strength of sketching in conveying the foundational elements and spatial dynamics of ideas, even as it may struggle with more abstract or innovative aspects.

3.2 Collaboration Effectiveness

The co-design session received an average effectiveness rating of 4.6 out of 5 from participants, indicating successful collaboration. This high score reflects the session's inclusive and structured nature, which enabled active engagement and shared decision-making, resonating well with the participants.

User participants felt a strong sense of belonging and contribution to the process. One participant's feedback illustrates the session's impact: "It was super valuable! I felt heard and that my problem was being addressed by someone who wanted to help me." Such expressions underscore the personalised and attentive approach of the session, diving deep into individual concerns and facilitating a meaningful design process. As another participant noted, the ability to articulate personal experiences and challenges, "Talking about my experience helped me find the pain I had," enhanced collective understanding and provided individual insights, demonstrating the transformative potential of collaborative design practices.

Professional participants reported the session presented a unique set of challenges, particularly in guiding participants without imposing on their creative autonomy. The delicate balance required in the facilitation process is captured by one professional's reflection on the difficulty of "Jumping into the interview - pushing a concept while also just wanting to get their insights," demonstrating the struggle to encourage independent thought and creativity while resisting the urge to lead their thinking. Another participant noted "the challenge of prompting participants to start drawing without suggesting specific ideas further," emphasising the professionals' endeavour to reduce their bias in the co-design process. Moreover, the transition from closed or leading questions to a more open-ended dialogue, as one professional reported, "It was hard to ask the right questions," highlights the shift required in their approach to communication. The session environment served as a pivotal learning experience for professionals, teaching them the importance of maintaining an unbiased stance, crafting open-ended questions, and adeptly guiding participants through the design process.

3.3 AI-Render Effectiveness

Vizcom scored a 3.7 out of 5 for accurately conveying user ideas. This moderate level of satisfaction indicates areas for improvement. Qualitative feedback from participants cited instances where the tool missed crucial contextual elements and struggled to interpret abstract design elements, highlighting the need for improved algorithmic understanding of user inputs. Additionally, participants desired more lifelike and detailed visualisations in the tool's rendering capabilities. One participant noted, “The render looks impressive, but some of the details are off, like heating bread- the wavy heat lines were interpreted as cables.”

3.4 Varied Discipline Response

The study evaluated students who were trained in visualisation and others who were not. Industrial Design (ID) students rated themselves more comfortable than the other disciplines presenting a Vizcom render. Of the other disciplines, 18% stated they were "uncomfortable" to "very uncomfortable" presenting their ideas with Vizcom. In contrast, none of the ID students stated they were uncomfortable presenting the AI-rendered image. All disciplines generally recommend Vizcom as a tool for co-designing sessions in the future; however, Industrial Design students are a more likely scoring 4.5 out of 5.0.

4 DISCUSSIONS

4.1 AI Performance and Integrity

Participants stated that although Vizcom could capture the general idea of their concepts, it missed specific details or original elements. We expect that as AI technology improves, its ability to interpret and visually represent user-generated ideas will become more precise. The emergence of AI in the design realm presents opportunities and challenges regarding performance and conceptual integrity. AI algorithms will need to discern and translate the nuanced intentions behind user sketches and prompts while ensuring that the essence of the original idea is amplified, rather than lost, through the intervention.

4.2 AI as a Co-Design Partner

The increasing use of generative AI in design is introducing a new era of collaboration where AI is seen as a partner rather than just a tool. This partnership requires human input to prioritise design aspects such as empathy, intuition, and subjective judgment. AI can potentially provide valuable insights and connections that can be easily accessible. When designers treat AI as a partner in the design process, they can use its computational power and data-processing abilities to explore a broader range of design options, fostering a collaborative partnership where human creativity and AI intelligence complement each other to achieve potentially superior outcomes.

4.3 Balance in AI & Designer Partnership

Using AI as a tool for co-creation between users and designers raises concerns about its long-term efficiency and effectiveness. While AI has the potential to streamline the design process significantly, there is a threshold to its utility, particularly if the input of ideas and information from users does not yield productive concepts. This scenario prompts a critical examination of whether AI's usefulness in the creative process is finite, especially considering the time invested. It brings to light the possibility that a designer adept in research methodologies and rapid visualisation techniques might offer more value in specific contexts. This comparison prompts the creative industry to weigh the benefits of AI against the nuanced and irreplaceable human touch that a skilled designer brings to the process.

4.4 Improvements to the Co-Design Vizcom Process

To enhance the co-design process with Vizcom, AI users should be given more time and opportunities to engage with the tool than our one-hour workshop allowed. As users become more familiar and comfortable with AI-assisted design, they will utilise its capabilities more effectively. Additionally, facilitators leading co-design sessions should refine their skills to foster an environment that encourages open dialogue and unbiased exploration of ideas, explicitly training facilitators to ask open-ended questions and minimise their influence on the creative direction of the session. Extending the co-design experience beyond the classroom and involving real-world users can provide invaluable insights and feedback, grounding the design process in user needs and contexts.

5 CONCLUSIONS

According to the study, incorporating AI tools such as Vizcom in the co-design process presents potential benefits but notable limitations that require attention. The findings expose the necessity for significant enhancement in AI's capacity to comprehend and visualise intricate human inputs. Nonetheless, as AI tools advance and improve their accuracy in response to the complex output of human imagination, our design processes and interactions with AI will inevitably evolve.

It is crucial, however, to ensure AI tools complement rather than replace human creativity. One participant noted, "The AI tool is a great addition to our toolkit, but it must support rather than override the creative process." Introducing AI into the co-design process can allow designers, end-users, and AI

to work together to develop innovative, user-centric solutions that reflect collective input. This study exposes opportunities and issues in implementing this method in future co-design practice.

REFERENCES

[1] Sanders E.B.-N. and Stappers P.J. Co-creation and the new landscapes of design. *CoDesign, International Journal of CoCreation in Design and the Arts*, 2008, 4(1), pp.5-18.

[2] Fleischmann K. The Democratisation of Design and Design Learning – How Do We Educate the Next–Generation Designer. *International Journal of Arts & Sciences*, 2015, 8.

[3] Cremers A. H. M., Neerincx M.A. and de Jong J.G.M. Inclusive Design: Bridging Theory and Practice. In *Engineering Psychology and Cognitive Ergonomics. Applications and Services. EPCE 2013*, 2013, Lecture Notes in Computer Science, vol 8020. Springer, Berlin, Heidelberg.

[4] Nikolić M., Škec S., Martinec T. and Horvat N. The Role of Sketching Activities and Outcomes in Conceptual Design Phase. Proceedings of the Design Society: *International Conference on Engineering Design ICED'19*, 2019, 1(1):399-408.

[5] Chen J.-F., Ni C.-C., Lin P.-H. and Lin R. T. Designing the Future: A Case Study on Human-AI Co-Innovation. *Creative Education*, 2024, 15, 474-494.

[6] Longo G., Middleton D. and Albano S. Elaborating a framework that is able to structure and evaluate design workflow and composition of Generative AI visualizations. *In Human Interaction and Emerging Technologies (IHIET-AI 2024): Artificial Intelligence and Future Applications*. 2024, AHFE Open Access, vol 0. AHFE International, USA.

[7] Eujin P., Campbell I. and Evans M. A Taxonomic Classification of Visual Design Representations Used by Industrial Designers and Engineering Designers. *The Design Journal*, 2015, 14, no. 1: 64–91.

[8] Kuys B., Ranscombe C. and Zhang W. Visualising product concepts to engage manufacturers with little or no industrial design capability. *Design Studies*, 2023, 87.

[9] Tohidi M., Buxton W., Baecker R. and Sellen A. User sketches: a quick, inexpensive, and effective way to elicit more reflective user feedback. In Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles (NordiCHI '06), 2006, New York, NY, USA, 105–114.