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EXPLORATION OF AI-DRIVEN FURNITURE DESIGN EDUCATION: A WORKSHOP CASE STUDY

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PAPER ABSTRACT: This abstract describes a study that was conducted to explore the potential of using artificial intelligence (AI) in furniture design education. Prior research has shown that text-based interaction and generative AI can support idea generation, and some studies suggest that AI should be considered as a co-creator rather than just a tool. However, there is a lack of research specifically on incorporating AI into furniture design education. The study was held in June 2022 as an online workshop and attended by 15 industrial design students. The workshop used a Generative Adversarial Network (GAN) to generate inspirational images for the students to use as inspiration for their designs. The students were divided into teams and were asked to select relevant images generated by AI and use them to come up with various ideas. They were also prompted to engage in a "Quick & Dirty Sketch Session" to be creative and unrestricted in their designs. After the workshop, participants completed a survey to provide feedback on their experience of using AI in the design process, and the survey aimed to gather information on the workshop experience, the methods and tools used, as well as the participants' satisfaction level and overall effectiveness of using the AI tool in the furniture design process. The paper presents the results of the study and delves into several key areas, including the re-definition of idea sketching, the significance of providing a transparent design process, and the ethical considerations associated with the utilization of AI in design fields.

Keywords: Artificial Intelligence (AI), Furniture Design Education, Generative Adversarial Network (GAN), Idea Generation, AI and Ethics

1. INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) in the field of art has been closely monitored. The initial deployment of AI as an assisting tool for the artwork was insufficient in its capabilities. For instance, the robot produced only monochromatic images at a sluggish pace in 1979, necessitating artist intervention for coloring to finalize the artwork (Garcia, 2016). Nonetheless, it has been observed that AI has progressed to the point of being able to produce concept art and even winning fine arts competitions. For instance, in 2022, a piece of artwork generated by AI secured the top position in the fine arts competition at the Colorado State Fair (Teoh, 2022). The victory triggered a debate regarding the suitability of AI-generated artwork for participation in such competitions.

Given that art and design share commonalities, particularly in terms of the need for creative visualization of ideas, it is imperative to gain a deeper understanding of AI's capabilities to ascertain how much designers can utilize or collaborate with AI tools. Notably, there is an AI tool that aids in producing

photorealistic renderings and design recommendations based on designers' initial sketches, such as Viscom AI (https://www.vizcom.ai/).

Furthermore, certain AI tools, such as Midjourney (www.midjourney.com) and Dall-e (https://openai.com/research/dall-e), have the capacity to generate digital images from natural language descriptions or prompts. AI software can respond to a text prompt, namely, “an armchair shaped like an avocado.” The resulting images depict various armchairs that emulate the form of an avocado with the seed transformed into the seat cushion.

The furniture design industry has especially witnessed a successful utilization of AI in the creation of chairs. One notable example is the use of generative design, a design exploration technology that permits designers and engineers to input their design goals alongside variables such as material, manufacturing methods, and cost restrictions along with form development. The software then generates a range of design alternatives by exploring all possible permutations of a solution, and through iterations, it learns from each design to determine what works and what does not per feedback input by the designer. For instance, in 2019, Philippe Starck collaborated with AI to design a chair for Kartell. Using generative software developed by Autodesk, the designer created a prototype for the chair (Jordahn, 2019). The software optimizes designs for functional requirements, such as maximum stability at the lowest weight, leading to the creation of a highly functional and aesthetically pleasing chair design.

Another example, The chAIr Project, is a series of four chairs that were co-designed by AI and human designers, aimed at exploring a collaborative creative process between the two (Schmitt, n.d.; Schmitt & Weiss, 2018; Weiss, n.d.). Schmitt and Weiss employed a Generative Neural Network (GAN) to generate images of chairs. The training dataset consisted of 562 chair designs from the 20th century, gathered through web scraping from Pinterest. Notably, different from Philip Starck’s chair, the GAN technology used for the project did not involve any further refinement of the generated images, which were kept in an abstract state. Instead, the AI-generated visual prompts, in the form of abstract images, were provided to human designers who transformed them into tangible chairs through manual sketching and rendering. The human designer was challenged to interpret and translate these abstract images into three-dimensional forms consisting of components and functions that could be recognized by other humans as a chair.

Both projects showcase the potential of AI tools influencing furniture design process and open new possibilities in creative works. This is perhaps attributed to furniture design being heavily driven by form and aesthetics that visual AI generative tools can bring in great influences. And with the rich history of furniture design, it provides the AI generative tool solid database. However, despite the existence of numerous AI tools available for furniture design, there is a lack of research documenting the experiences of designers who utilize these tools in their design process. The aim of the present study is to investigate

the experiences of furniture design students who utilized an AI tool in their design process. Specifically, the AI generated images provided by Schmitt and Weiss from The chAIr Project were employed to inspire students to facilitate idea exploration.

2. METHODS

In 2022 summer, an online Technology-Driven Design Workshop was conducted to provide participants with an opportunity to learn about the technology-driven design process. The workshop attracted 15 industrial design students from Tatung University (Taipei, Taiwan). As part of the workshop, students experienced how to generate ideas inspired by abstract furniture-look-like images generated by AI.

To provide more clarity, each group of 3-4 participants was assigned a random interior space, ranging from a brightly romantic café to a modern and moody store. The participants were instructed to identify keywords that came to mind when observing the provided interior images including but not limited to adjectives describing the interior vibe, colors, forms, elements, emotions, etc. (see Figure 1). Subsequently, they were given the freedom to select any number of AI-generated images that aligned with their chosen keywords (see Figure 2). Their next step involved narrowing down their selection to the top five images that they believed could be transformed into functional seating designs for their assigned interior space (see Figure 3). Finally, the participants engaged in a Quick & Dirty Sketch Session aiming to nurture creative, bold, and unrestricted design. This activity drew inspiration from the selected AI images in response to the specific interior space.

Figure 1. Overview of Workshop Process: Extracting keywords from assigned interior space images.

Figure 2. Overview of Workshop Process: Selecting AI-generated images corresponding to chosen keywords.

Figure 3. Overview of Workshop Process: Narrowing down to 5 images to proceed with ideation.

Post-workshop, the attendees were invited to complete a survey that aimed to evaluate their experience in using AI in the design process (See Appendix for survey questions). Specifically, the participants were asked to provide their feedback on the workshop, assess the effectiveness and satisfaction level of the methods and tools employed, and rate the overall efficacy of utilizing AI in the furniture design process. The survey procedure and questions were reviewed and approved by Kansas State University IRB (IRB Protocol Number 11270).

3. RESULTS

In this workshop, four different interior spaces were assigned to different participants (See Figure 4). Due to the length of workshop hours and the participants being at a variety of education levels, the design outcome stayed in a preliminary ideation stage and in sketch form only. The participants were able to generate seating design ideas despite not having previous experience in furniture design. Additionally, an interesting finding was how participants utilized the workshop elements (interior images, keywords, and AI-generated images) in variation to assist their design process. See Figure 5 and 6 for examples of the design process and outcome sketches.

Figure 4. Examples of two of the interior spaces that were assigned to the participants (Left: Revo Café / Right: Volgare Store), images from Google search.

Figure 5. AI-generated images selected by two of the participants from their extracted keywords (Left: Participant A / Right: Participant B).

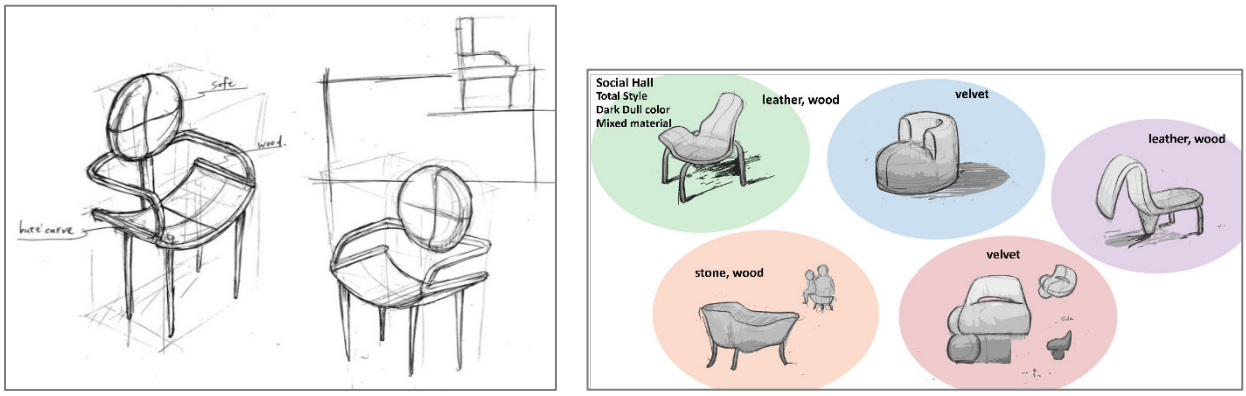

Figure 6. Sketched outcomes from two of the participants (Left: Participant A / Right: Participant B).

Out of the 15 participants who attended the workshop, nine of them completed the survey. All participants were industrial design students, comprising five graduate and four undergraduate students (see Figure 7, Left). The results of the survey are synthesized into two themes as follows: 1) overall workshop experience, 2) AI tool experience: satisfaction level of using the tool, and 3) AI tool experience: effectiveness to inspire new furniture design development.

3.1 PARTICIPANTS

In terms of previous experience with technology-driven new product development projects, including AI-driven design processes, more than half of the participants (55.55%) did not have any prior experience before attending the workshop (see Figure 7, Right). This implies that the workshop was successful in introducing participants to new design approaches that utilize AI-generated images.

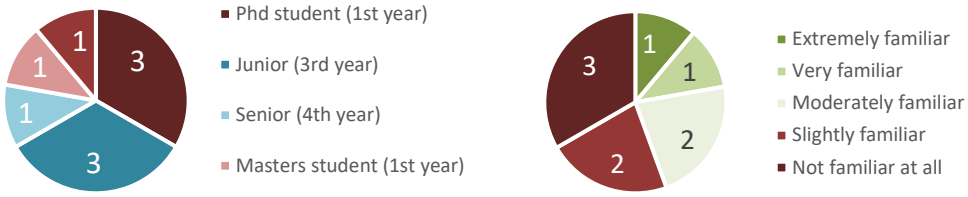

Figure 7. Survey Results: Left-Participant Demographic information, Right-Level of Familiarity with the Introduced AI tool.

3.2 WORKSHOP EXPERIENCE

When asked about their favorite aspects of the workshop, the participants mainly mentioned the benefits of learning a new design approach using AI. Specifically, they appreciated learning about the AI tool's role in the design process and what it can do in design. On the other hand, when asked about their least favorite aspects of the workshop, the participants mainly mentioned the workshop activities, particularly the limited time allotted for them. They suggested that having more time to create physical prototypes and selecting appropriate AI images would be beneficial.

3.3 AI TOOL EXPERIENCE: SATISFACTION LEVEL OF USING THE TOOL

Regarding the level of satisfaction with the usage of the AI tool during the workshop, participants mentioned the main benefit of the AI tool as an inspiration-driven method for furniture design at a conceptual level. Participants acknowledged the potential of abstraction in fostering divergent thinking and generating a diverse range of design ideas. For instance, one participant noted that "It was interesting to see the generated AI image help to diversify ideas even working on designing chairs for the same space."

3.4 AI TOOL EXPERIENCE: EFFECTIVENESS TO INSPIRE NEW FURNITURE DESIGN DEVELOPMENT

The survey participants all agreed that the tool is effective in inspiring new furniture design development (a 5-point Likert scale ranging from strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, not agree, see Figure 8). To enhance its effectiveness, one participant suggested that having an additional AI tool assisting in selecting texture images during the idea sketching phase would improve the effectiveness of the sketching process.

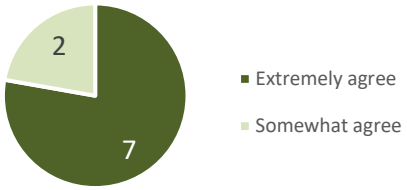

Figure 8. Survey Results: Effectiveness of the AI Tool to Inspire New Furniture Design Development.

4. DISCUSSION

Overall, the workshop provided participants with the opportunity to learn about the technology-driven design process using AI-generated images. The participants' feedback on the workshop and the AI tool's usage suggests that using AI-generated images can be an effective method for inspiring new furniture design development. However, future workshops should take into account the participants' suggestions to improve the workshop's effectiveness. Based on the survey results, it is suggested that future workshops should allocate more time for workshop activities to provide participants with sufficient time to create physical prototypes. Additionally, an additional AI tool assisting in selecting texture images during the idea sketching phase should be considered to improve the effectiveness of the sketching process.

The workshop results generated interesting discussions, such as the abstraction of ai-generated images in the design inspiration phase, the importance of presenting the design process when collaborating with AI, and AI and ethics. The following sections will discuss these topics.

4.1 ABSTRACTION OF AI-GENERATED IMAGES IN THE DESIGN INSPIRATION PHASE

The recent advancements in text-based AI tools have enabled the rapid generation of various design directions and details in a matter of hours, given suitable text prompts. Also, the Viscom AI platform facilitates designers in transforming their initial conceptual napkin sketches into high-resolution photorealistic renderings within a minute (Thai, 2023). However, within the concept art community, designers have expressed frustration with their role as mere curators of AI-generated images, rather than active creators of the final concept art. Some designers also have raised ethical concerns regarding the use of AI-generated images, which are often sourced from online repositories without obtaining prior consent from their rightful owners and creators. Such practices raise questions about the ethical implications of utilizing AI in the creative process and highlight the need for more comprehensive and responsible use of this technology.

In the context of the abstract level of AI-generated images created by GAN, participants in a recent workshop appeared to have little or no concern about the potential invasion of their creativity by the AI tool. It may be important to incorporate some level of abstraction in the idea exploration phase to cultivate the creativity of design students and develop their essential design skill sets. One possible approach to utilizing AI as a design tool for inspiration found from the previously published article is to generate mood boards using Midjourney (Williams, 2023). This approach could enable novice designers to utilize the outcomes generated by AI for their design inspiration, rather than simply making minor adjustments to the photo quality rendered AI-generated images and claiming authorship of the final design outcomes. Additionally, further development in 3D and/or prototyping would encourage the design students to transform the 2D images into tangible solutions. Take furniture design as an example, designers will face the challenges of bringing conceptual graphics into the real world by making design decisions considering aspects such as structure, materiality, joinery and fabrication. By adopting a more

thoughtful and intentional approach to incorporating AI in the design process, designers can maximize the benefits of this technology while also preserving their creative autonomy.

4.2 PRESENTING DESIGN PROCESS COLLABORATION WITH AI

The recent case of an AI winning first place in a painting competition raises interesting questions about people's perceptions and values regarding creative outcomes. It is possible that people's perceptions of the drawing or even the pricing of the drawing could differ based on whether they knew that the drawing was created entirely by AI or by a human artist. It is therefore crucial to gain a deeper understanding of what people value in creative outcomes. Is it solely based on the quality of the outcome, or do people also consider the amount of time, effort, and creativity invested in the creation process? It is possible that both aspects are important to users and audiences. Further research is needed to explore these issues and gain a better understanding of people's perceptions and values regarding creative outcomes in the context of AI-generated artwork.

In the field of design, collaboration with AI is gaining popularity, and as a result, it has become increasingly important to showcase the design process to clients, employers, or colleagues. It is not merely about displaying the final product, but rather about presenting the process of how the final product was created, including curation and calibration of the AI-generated designs followed by the refinement process. Note that curation and design refinement skills are becoming more important in AI collaboration in the design process (Improbable Future, 2023). Consequently, it may become essential to educate design students on this skill set, and they should be trained to exhibit their design process along with the final product in their portfolio. The authors contend that design students need to demonstrate their ability to work with AI tools, including the generation of design ideas, curation process, and calibration of the AI models to suit their design requirements. In addition, showcasing the refinement process is crucial since it indicates the designer's ability to evaluate and improve their work through iteration. Hence, presenting the design process when collaborating with AI is of great significance, and it is necessary to educate design students on this aspect to prepare them for the real-world design industry.

4.3 AI AND ETHICS

The development of AI has raised concerns among artists and designers about the potential for job displacement, reminiscent of the displacement that occurred after the First Industrial Revolution. The fear of losing jobs to machines has historical precedent, as seen in the Luddite movement of 1812, in which factory workers destroyed machines that were taking their jobs, seeking to return to the previous way of doing things. However, instead of fearing AI as a job killer, it is important to consider how it can be used in an ethical way to benefit humans.

Ethical consideration in the development of technology is important as it sets the right direction to not harm human rights. For instance, during World War II, the Nazi regime conducted horrific experiments

on human subjects in concentration camps, including testing the effectiveness of new drugs and chemicals. While these tests might have given scientists insights to develop better technologies for drugs and chemicals for certain purposes, these experiments were not only inhumane but also lacked ethical consideration for the human subjects involved. This example highlights the importance of ethical guidelines and oversight when developing and using technology.

In the case of AI, it is crucial to consider the ethical implications of its use and to ensure that it is being used in a way that benefits humans, including designers and users, rather than causing any potential harm. The development of ethical frameworks and regulations is important to ensure that AI is used in the right way in an ethical and responsible manner. Institutional Review Boards (IRBs) was established to ensure the ethical way of conducting human subject research, and similar oversight may be beneficial for the development and deployment of AI in product development.

Furthermore, it is important to consider how AI can help and collaborate with designers in an efficient and ethical manner to create designs that are beneficial for end-users as well as designers. AI can be used to augment and enhance human creativity and design skills, allowing for more efficient and innovative product and furniture design. However, the development of AI should not be seen as a replacement for human designers, but rather as a tool to assist and collaborate with them.

One potential solution to address ethical concerns associated with AI-generated images is to adopt a personalized approach that leverages an individual designer's own sketches and utilizes the images that have been specifically permitted for use in the design process by the respective content owners. This approach, which is similar to the Stable Diffusion and Astria models (Vohra, 2023), can provide designers with greater autonomy and control over the images used in the design process, while also ensuring that ethical considerations are upheld. In this way, the ethical development and use of AI can lead to a more beneficial and harmonious relationship between humans and technology.

4.4 LIMITATIONS AND FUTURE STUDIES

The present study provides an initial exploration of designers' experiences with an AI tool, and as such, the survey questions were limited in scope. In order to collect more nuanced and in-depth data, future research will need to refine the survey questions and employ more qualitative methodologies. Additionally, the sample size of the study was relatively small, and therefore the findings may not be generalizable to the broader population of designers. To increase the validity of the results, future workshops should include a larger and more diverse sample of participants. Current study utilizes AI generated images focusing on seating design only, broadening the materials to other furniture categories, such as tables and cabinets, would allow researcher to investigate the full potential of incorporating GAN in furniture design process. Furthermore, while the current study focused on the use of GAN for idea generation, future research should incorporate other AI tools, such as those designed for sketching and rendering, to obtain a more comprehensive understanding of designers' experiences

with AI. Ultimately, the findings of this and future research will be valuable for AI tool developers seeking to enhance the usability and effectiveness of their tools for designers.

5. CONCLUSIONS

In conclusion, the use of AI in art and design has progressed significantly, with AI tools able to produce concept art and furniture design concepts. The use of generative design and GAN technology has enabled designers to optimize their designs and generate inspirational images for idea exploration. However, there is a lack of research documenting the experiences of incorporating AI tools in the design process of furniture design education. The present study aimed to investigate the experiences of industrial and furniture design students who utilized a GAN tool in their design process. The workshop provided participants with an opportunity to learn about the technology-driven design process and generate ideas inspired by images generated by AI. The survey results from the participants showed that learning a new design approach using AI was the most appreciated aspect of the workshop, while the lack of prior experience with the AI tool and technical difficulties were the least appreciated aspects. Overall, the efficacy of utilizing AI in the furniture design process was rated positively. Discussions in this paper included the abstraction of AI-generated images, presenting the design process when collaborating with AI, and AI and ethics. It is crucial to incorporate some level of abstraction in the idea exploration phase to cultivate the creativity of design students and develop their essential design skill sets. Additionally, it is essential to educate design students on curation and design refinement skills, along with the process of how the final product was created when collaborating with AI. Finally, ethical considerations in the development of technology are essential to avoid harm to human rights.

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7. APPENDIX: SURVEY QUESTIONS

Note: Only relevant questions to the study of AI and Furniture Design Process were selected to be shown here.

Title: 2022 Technology-Driven Design Workshop Post Survey

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Thank you so much for attending Technology-Driven Design Workshop, and for taking the time to leave feedback about your experience. This survey will take about 30 minutes. To participate in this survey, you must attend the 2022 Technology-Driven Design Workshop and is fluent in English. You will be asked to provide your workshop experience along with evaluating the methods and tools learned from the workshop. You are not guaranteed any personal benefits from the survey. You might hesitate to participate and drop out of the online survey because of confidentiality. Any data to identify your identification will not be published. Your participation is voluntary, and you can choose to stop participating at any time without penalty. Please contact PI with any questions. Clicking the "next" button indicates that you have read, understand, and agree to participate in this study.

Q: What is your major?

- Industrial Design
- Others (please specify) _____

Q: Which year are you in?

- Sophomore (2nd year)
- Junior (3rd year)
- Senior (4th year)
- Masters student (1st year)
- Masters student (2nd year)
- Phd student (1st year)
- Phd student (2nd year)
- Phd student (3rd year)
- Phd student (4th year or more)
- Others (please specify) _____

Q: Have you had any experience working on technology-driven new product development projects prior to the workshop?

- Yes
- No

- Maybe

Q: What did you like the most about Project: AI and Furniture Design?

_____
_____
_____
_____
_____

Q: What did you like the least about Project: AI and Furniture Design?

_____
_____
_____
_____
_____

Q: Were you familiar with Generative Adversarial Network (GAN) prior to the workshop?

- Extremely familiar
- Very familiar
- Moderately familiar
- Slightly familiar
- Not familiar at all

Q: Did you find the AI method and tool effective to inspire new furniture design development?

- Extremely agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Extremely disagree