The Effect of AI Integration on Designers' Creativity in the Sketching Process for Design Ideation

디자인 아이데이션 스케치 과정에서 AI의 활용이 디자이너의 창의성에 미치는 영향

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Abstract

This study proposes the hypothesis that the use of AI-based design sketch tools differs in terms of creativity compared to traditional sketch tools, such as pencil and paper. To investigate this hypothesis, experiments and surveys were conducted, targeting designers with experience using AI tools. In the experiment, both traditional sketch methods and AI tools were utilized during the ideation process. The AI tools were limited to ChatGPT 4.0 and DALL-E.

The results of the study were analyzed using an independent samples t-test to compare the creativity scores between the group utilizing AI tools and the group using traditional tools. Additionally, the relationship between the designers' skill level and creativity scores was analyzed using Pearson's correlation coefficient, revealing a strong positive correlation between these two variables. The study concludes that AI tools have a significant positive effect on design creativity, enhance work efficiency, and reduce revision time. However, further discussion and analysis suggest that, while AI tools accelerate idea generation and productivity, they may lack the depth of thought and relational considerations provided by traditional methods, which necessitates caution.

Keyword

Design Ideation Sketch(디자인 아이데이션 스케치), AI(인공지능), Creativity(창의성)

요약

본 연구는 AI 기반 디자인 스케치 도구를 사용하면 연필과 종이를 등 전통적인 스케치 도구와 비교했을 때 창의성에 영향을 미친다는 가설을 제기하고 이에 대한 실험과 설문을 통해 연구를 진행한다. 이를 위해 AI 도구 사용 경험이 있는 디자이너를 대상으로 실험을 진행하였으며, 실험에서는 전통적 스케치와 AI 도구가 아이디어 구상 과정에서 활용되었다. AI도구 중에서 Chat GPT4.0와 DALL-E만을 제한하여 사용하였다. 연구 결과는 독립 표본 t-검정을 통해 AI 도구를 활용한 그룹과 전통 도구를 활용한 그룹 간의 창의성 점수를 비교하였으며, 그 결과 AI 도구가 창의성에 통계적으로 유의미한 영향이 있음을 확인하였다. 더불어 디자이너의 기술 수준과 창의성 점수 간의 관계를 Pearson 상관계수를 통해 분석한 결과, 두 변수 간에 상관관계가 나타났다. 본 연구는 실험을 통해 AI 도구가 디자인 창의성에 영향이 유의미하며, 추가로 작업 효율성을 높이고, 수정 시간을 줄이는 데에도 유의미하게 영향을 미친다는 결론을 도출했다. 추가 논의와 토론을 통해 아이디어 생성 속도와 생산성을 높이긴 하지만 사고의 깊이나 관계적인 고려에 대한 부분은 실제 전통적인 방식보다 깊이가 떨어질 수 있기 때문에 주의가 필요하다고 지적한다.

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1. Introduction

1-1. Research Background

Designers utilize sketching as a fundamental process to communicate and develop ideas during the ideation phase or to visually represent design concepts. While there are various methods of sketching, it ranges from traditional techniques, such as using pencils and hand tools, to more contemporary approaches involving computer-based sketching tools. The use of pencils and coloring instruments enables designers to clarify and solidify their ideas with greater precision, while also serving as an effective communication medium with other designers and collaborators. This method is often the most direct and accurate way to convey design intentions.

If this sketching process were to be augmented by artificial intelligence (AI), it could potentially transform the way designers approach ideation.

AI has the potential to inspire designers in various ways[1]. Additionally, AI can provide a vast foundation of data that aids in generating new ideas[2]. By leveraging pre-trained language models in AI, designers can synthesize design ideas with external knowledge sources while ensuring the originality of the generated concepts[3]. Thus, the use of AI offers designers valuable assistance and enhances productivity.

1-2. Research Objectives

This study aims to explore and validate this question by examining the potential of AI as a tool for design ideation and its effectiveness in enhancing creative thought and productivity.

1-3. Research Method

This study involved a total of 40 designers, each with varying levels of experience in using AI tools. The research aimed to assess the impact of AI tools on creativity, work efficiency, and the relationship between designers' skill levels and their creativity scores.

1-3-1. Participants

The study recruited 40 designers with diverse levels of experience using AI tools. These

1) Y. Nur, Y. O. Chang, D. Sayar, V. Turri, J. Forlizzi, J. McCann, and J. Zimmerman, "Creating Design Resources to Scaffold the Ideation of AI Concepts," ACM Conference on Human Factors in Computing Systems, 2023.

2) J. Kim and M. L. Maher, "The Effect of AI-based Inspiration on Human Design Ideation," International Journal of Design Creativity and Innovation, 2023.

3) Y. Ying, S. Münster, T. Köhler, and C. M. Sommer, "Understanding the Industrial Designer's Self-perception of Ideation," International Journal of Design Creativity and Innovation, 2020.

participants were divided into groups based on their experience levels: beginner, intermediate, and advanced.

1-3-2. Creativity Analysis

An independent sample t-test was conducted to compare the creativity scores between the AI tools group and the traditional tools group. This analysis aimed to determine the statistical significance of the differences in creativity scores between the two groups.

1-3-3. Efficiency Analysis

To evaluate the efficiency of AI tools compared to traditional tools, an analysis of variance (ANOVA) was conducted. This analysis compared the differences in task completion time and revision time between the two groups.

1-3-4. Correlation Analysis

The relationship between designers' skill levels and their creativity scores was assessed using the Pearson correlation coefficient. The analysis aimed to explore whether higher skill levels were associated with higher creativity scores. The scatter plot used in this analysis displayed the correlation, with the X-axis representing designers' skill levels.

2. Theoretical Background

2-1. Design Sketch

Sketching arises from the need to refine the initial ideas that emerge as the first signs from the brain. It can be likened to "thinking through the hand," as each thought is extended and anchored in the moment through the hand gestures that register these ideas.[4]

Design sketching serves as a bridge between conceptualization and realization, playing a pivotal role across various disciplines. It facilitates ideation, problem-solving, and communication. Recent research highlights the multifaceted role of sketching, emphasizing its importance in both traditional and digital design processes. Sketching acts as an external memory aid, allowing designers to visualize and associate non-visual information, thereby fostering creativity[5][6]. By providing a physical medium to structure design thinking, it enables real-time exploration of ideas[7]. Hybrid digital tools, utilizing algorithms[8] to expand conceptual boundaries, have been developed. While sketch-based modeling (SBM) has advanced in fields such as mechanical engineering, current tools often prove less effective than traditional sketching methods. Despite technological advancements, sketching remains essential in design education, enhancing critical thinking and problem-solving skills[9].

Although sketching is highly valued, some argue that increasing reliance on digital tools risks diminishing the traditional importance of tactile and intuitive aspects of design. Sketching serves as a fundamental method for designers to capture initial ideas, acting as "thinking through the hand[10]" to transform mental concepts into

4) A. Moreira da Silva, "Sketches versus Artificial Intelligence Systems in Design Creative Process," AHFE Conference, 2023.

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6) CC. Brokaw, "Sketching Role in Nowadays Design Education," Springer Series in Design and Innovation, 2022.

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9) D. Jorge, P. Company, and F. Naya, "Sketch-Based Modeling in Mechanical Engineering Design: Current Status and Opportunities," Computer Aided Design, Vol. 5, 2022. doi: 10.1016/j.cad.2022.103283.

10) A. Moreira da Silva, "Sketches versus Artificial Intelligence Systems in Design Creative

visual forms. It stimulates a cycle of reinterpretation during idea generation, enabling designers to explore new connections and directions, ultimately enhancing creativity[11]

2-2. AI and Design Sketch

AI has revolutionized the design process by efficiently analyzing complex data and enhancing the understanding of user needs[12]. The integration of AI into industrial design has significantly improved design efficiency[13]. By leveraging AI in industrial design, designers can analyze complex data more effectively, apply technically challenging calculations in a short time, and innovate existing designs[14].
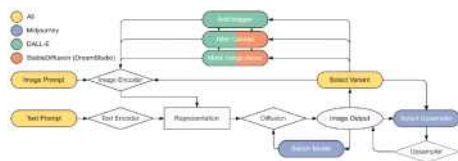
[Figure 1] Model architecture and image generation process in different models. Grey elements show the AI workflow, coloured elements the user interaction[15]

Programs such as ChatGPT and DALL-E and

generative design have been studied for their potential to support and enhance the industrial design ideation process[16]. Generative machine learning models, like ChatGPT, have proven to be valuable tools in fostering the generation of new design concepts, supporting various stages of design such as ideation, initial prototyping, and sketching. Notably, applying AI tools like ChatGPT and DALL-E in the design thinking process has been shown to improve the efficiency and creativity of user interface design during the definition and ideation phases[17]. The capabilities of ChatGPT provide designers with access to vast amounts of relevant information within the design process, significantly influencing informed decision-making. The use of deep learning-based autoregressive language models aids in generating human-like sentences, facilitating routine design tasks and decision-making processes[18].

The use of AI and generative machine learning models supports creative design processes by enhancing ideation, early prototyping, and sketching[19]. Combining AI with human input introduces new forms of self-expression and communication, offering potential for artistic expression within the design process[20]. AI learning models offer opportunities

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11) A. Moreira da Silva, "Creativity and Emotion in Design," Ergonomics in Design, 2022.

12) Z. Feng, "Design and Implementation of Industrial Design and Transformation System Based on Artificial Intelligence Technology," Mathematical Problems in Engineering, 2022.

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17) B. Ahmet and B. Kocaballi, "Conversational AI-Powered Design: ChatGPT as Designer, User, and Product," arXiv.org, February 2023.

18) G. Abduallah, "ChatGPT: Virtual Creative Model," NIF Journal, 2023.

19) T. Jakob and M. Jonsson, "Design Ideation with AI – Sketching, Thinking and Talking with Generative Machine Learning Models," ACM Conference on Human Factors in Computing Systems, 2023.

20) P.-K. Hung and R.-H. Liang, "Designing with AI: An Exploration of Co-Ideation with Image Generators," ACM Symposium on User Interface

to support various aspects of the design process. The application of ChatGPT to content generation within a short timeframe demonstrates its efficiency and potential as a tool in the creative process. It is crucial to implement AI early in the design process, as it highlights the need for new collaborative practices and the integration of knowledge[21].

2-3. AI and Design Ideation

A review of previous studies in the design field reveals that AI has been explored from multiple perspectives, including improving efficiency, fostering creative thinking, and utilizing data. These studies have investigated various approaches to integrating AI into the design process. A summary of these studies is provided in the table below.

[Table 1] Methods of Utilizing AI for Design Ideation

Methods		Design Ideation
Style Variation Using AI-based Image Generation Tools	Style Variation Using AI-based Image Generation Tools	By using deep learning models to generate images in various styles, designers can obtain drafts or gain new inspirations.
	Style Variation Using AI-based Image Generation Tools	Style transfer techniques, which apply a specific style to another image, can be quickly and diversely experimented with using AI.
Text-based Idea Generation	Natural Language Processing (NLP) Models	AI tools like ChatGPT are useful for generating text-based ideas. By asking the AI to describe a design concept or propose ideas for specific design

Software and Technology, 2023.

21) O. Jesús, A. Vásquez-Hernández, Z. Giménez, and L. F. Alarcón, "Ideation Framework in Industrialized Construction," Annual Conference of the International Group for Lean Construction, 2022.

		challenges, it can provide valuable suggestions.
	Brainstorming	Brainstorming can be conducted through conversations with AI. The AI suggests related keywords, trends, or successful design examples from the past, helping to broaden the scope of ideas.
Identifying Trends through Data Analysis	Data-driven Insights	AI can analyze social media, search trends, user feedback, and other data to identify popular design elements, colors, and more in the current market. Based on this data, trendy design ideas can be generated.
	Predictive Modeling	AI can predict future trends based on past data. This allows for the planning of designs that incorporate anticipated trends in advance.
Automating the Design Process	AI Design Tools	AI-based design tools automatically suggest layouts, recommend color combinations, and automate repetitive tasks. This allows designers to focus more on creative work.
	Prototype Generation	AI quickly generates design prototypes, simplifying the process of visualizing ideas.
Collaboration and Feedback	AI Feedback System	AI can provide feedback on generated designs and suggest areas for improvement. For example, it can offer advice on color contrast or layout balance according to basic design principles.
	User Testing Simulation	AI can predict user experience through virtual user tests and suggest improvements.
Reference and Research Tools	Image Search and Analysis	AI-powered image search tools quickly find reference images that match a specific style or theme. Additionally, AI can analyze similar designs to identify which elements

	contribute to their success.
Creative Brief Generation	AI analyzes the requirements of a design project and automatically generates a creative brief based on that analysis.

2-4. The Relationship Between AI and Design Creativity

Numerous studies have examined the impact of AI tools versus traditional tools on creativity. These studies offer various perspectives on how AI tools are utilized in design, art, and creative work, and whether these tools genuinely enhance or hinder creativity. Boden[22] explored the concept of creativity and theoretically analyzed how AI can contribute to creative tasks, suggesting that AI tools can serve as a supportive role in the creative process. McCormack et al.[23] investigated how AI systems can independently contribute to creative work. Their study analyzed cases where AI generated creative outputs in fields such as art, music, and literature, and explored how these systems support or potentially replace human creativity. The findings concluded that while AI can complement human creativity, it cannot fully replace it.

Zhao and Wang[24] conducted an experimental study comparing creative tasks performed with

22) Boden, M. A. (1998). 'Creativity and Artificial Intelligence: A Theoretical Overview'. Artificial Intelligence, 1998, 103(1–2), pp. 347–356.

23) J. McCormack, T. Gifford, and P. Hutchings, "Autonomy, Authenticity, Authorship and Intention in Computer Generated Art," International Conference on Computational Creativity (ICCC), 2019.

24) H. Wang, J. Zou, M. Mozer, A. Goyal, A. Lamb, L. Zhang, W. J. Su, Z. Deng, M. Q. Xie, H. Brown, and K. Kawaguchi, "Can AI Be as Creative as Humans?," International Conference on Learning Representations (ICLR), 2021.

and without AI tools, quantitatively evaluating the differences in creativity. The results showed that AI tools reduce repetitive tasks, allowing for more time to be dedicated to creative thinking, thereby potentially increasing overall creativity scores. However, the study also warned that excessive reliance on AI tools could limit the sources of creativity to those generated by AI.

This body of research underscores the evolving nature of studying the impact of AI tools on creativity. While many studies highlight the positive influence of AI tools on enhancing creativity, they also emphasize that the effectiveness depends on how and in what context the tools are used. The way designers leverage AI tools can either amplify or restrict creativity, with the collaboration between humans and AI emerging as a critical factor.

3. Experimental Design and Procedure

Designers could generate more creative ideas using AI-based design sketching tools compared to traditional tools such as pencil and paper. This study aims to conduct an experiment. The research hypothesis is that design sketches created using AI tools will yield higher creativity scores than those produced using traditional tools: pencil and paper.

3-1. Research Subjects

A total of 40 designers were recruited, with a diverse range of experience in using AI tools. The participants were aged between 20 and 30, and all had graduated from design-related programs and are currently employed as industrial designers in design firms or research institutes. The participants were categorized based on their experience level: beginner (10 participants), intermediate (15 participants), and advanced (15 participants).

The experimental groups were divided as follows: Group 1 (AI Tools Group) utilized

AI-based design software to complete sketching tasks, while Group 2 (Traditional Tools Group) performed the same tasks using traditional tools (pencil and paper).

3-2. Task Setting

Each group was assigned the same design task: to create a design for a object on the table. Participants were instructed to freely express their design ideas based on the given theme. The task allowed for creative freedom and had to be completed within three hours.

3-3. Variable Setting

The independent variables in this study were the tools used (AI tools versus traditional sketching tools) and the designers' skill levels (beginner, intermediate, advanced). The dependent variables were as follows:

1. Creativity Score: An external expert panel evaluated the creativity, originality, and aesthetic elements based on five criteria, with each criterion rated on a scale from 1 to 10.

2. Work Efficiency: The time taken to complete each design task and the time required for revisions were measured.

3. Work Satisfaction: Post-task surveys assessed the designers' satisfaction with their work, rated on a scale from 1 to 5.

3-4. Data Collection and Analysis

A panel of five experts was established to assess creativity. Each panel member is composed of experts and educators with over 10 -15 years of extensive practical experience in industrial design and related fields. Each expert independently evaluated the designs, and the results were averaged to produce the final scores. To measure work efficiency, the start and completion times were automatically recorded, and a precise timing tool was used to calculate the duration. Data for work satisfaction were collected through standardized post-task surveys.

3-5. Ethical Considerations

The research objectives and procedures were thoroughly explained to the participants, and informed consent was obtained. All data were anonymized, and no personally identifiable information was collected, ensuring the participants' confidentiality.

3-6. Data Analysis

The above graph compares the creativity scores of 40 designers, divided into the AI tools group and the traditional tools group. The scores for each designer are represented as bar charts, with blue bars indicating the AI tools group and orange bars indicating the traditional tools group. This visual representation allows for a clear comparison of the performance of individual designers across both groups.

4. Results

4-1. Analysis of Creativity in the AI Tools Group and Traditional Tools Group

An independent sample t-test was conducted to compare the creativity scores between the two groups and to quantitatively assess the impact of AI tools on creativity. The graph above shows the distribution of creativity scores for both the AI tools group and the traditional tools group. The blue bars represent the AI tools group, while the orange bars represent the traditional tools group. As illustrated, the mean score for the AI tools group (7.5) is higher than that of the traditional tools group (6.5).
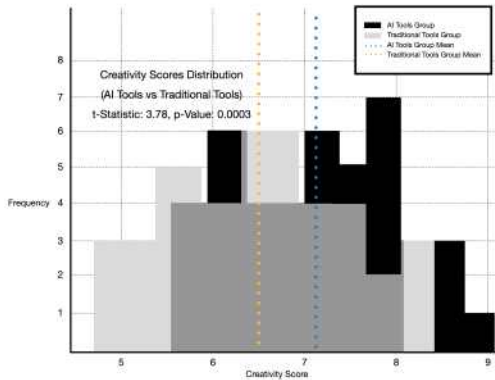
[Figure 2] Analysis of Creativity in the AI Tools Group and Traditional Tools Group

The results of the independent sample t-test are as follows:

t-statistic: 3.78

p-value: 0.0003

Since the p-value is much smaller than 0.05, the difference in creativity scores between the AI tools group and the traditional tools group is statistically significant. This finding suggests that the use of AI tools may positively impact design creativity.

4-2 Correlation Between Designers' Skill Level and Creativity Scores

To assess the relationship between designers' skill levels and their creativity scores, the Pearson correlation coefficient was calculated. The scatter plot above illustrates this correlation, with the X-axis representing designers' skill levels (1: Beginner, 5: Advanced) and the Y-axis representing creativity scores.

[Figure 4] Correlation Between Designers' Skill Level and Creativity Scores

The Pearson correlation coefficient of 0.89 indicates a very strong positive correlation. Additionally, the p-value is less than 0.001, confirming the statistical significance of this
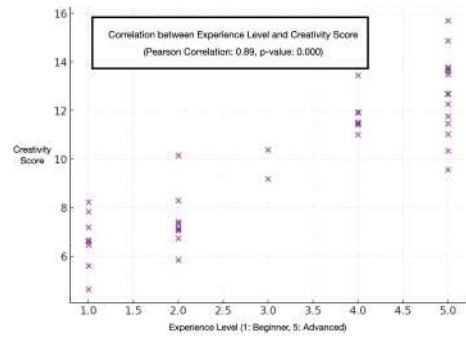
correlation. These results suggest that as skill levels increase, creativity scores also tend to rise.

5. Discussion

This study compared and analyzed the impact of using AI tools versus traditional tools on design creativity, work efficiency, and designers' skill levels. The experimental results indicate several significant differences, suggesting that AI tools may positively influence design creativity.

5-1. The Impact of AI Tools on Creativity

An independent sample t-test comparing the creativity scores between the AI tools group and the traditional tools group revealed that the average score for the AI tools group (7.5) was significantly higher than that for the traditional tools group (6.5) (t-statistic: 3.78, p-value: 0.0003). Given that the p-value is much smaller than 0.05, we can conclude that AI tools positively influence design creativity. Notably, the distribution of scores in the AI tools group showed a higher median and more concentrated range compared to the traditional tools group, indicating more consistently high creativity levels. These findings suggest that AI tools can contribute to the diversity of design ideas and the expansion of creative thinking.

5-2. The Impact of AI Tools on Task Time and Revision Time

Analysis of variance (ANOVA) comparing task time and revision time between AI tools and

traditional tools showed that both task time and revision time were significantly reduced when using AI tools. The AI tools group recorded shorter task completion times and required less time for revisions compared to the traditional tools group. This suggests that AI tools reduce the repetition in design work, enhance efficiency, and enable faster revisions. These results demonstrate the practical benefits of AI tools, allowing designers to quickly visualize creative ideas and make necessary adjustments with ease. By saving time on repetitive tasks and revisions, designers could allocate more time to the actual thinking process, thereby enabling multiple creative attempts and ultimately enhancing creativity.

5-3. Correlation Between Skill Level and Creativity

The Pearson correlation analysis between designers' skill levels and creativity scores yielded a correlation coefficient of 0.89, indicating a very strong positive correlation (p-value < 0.001). This result suggests that higher skill levels are associated with significantly higher creativity scores. Skilled designers are likely to utilize AI tools more effectively, enabling them to develop creative ideas and produce higher-quality design outcomes. Conversely, beginner designers may struggle to fully leverage the functionality of AI tools, leading to differences in creativity scores. However, because AI relies on human input data, achieving complete creativity may be challenging, and there were instances where the output differed from the original intent. Thus, traditional sketching processes may still offer more efficient means for fully expressing creative thought.

Although not derived from the data, expert opinions further support these findings. While AI can enhance creativity, it may also impose creative constraints. Experts noted that when AI suggests or generates design ideas, it can provide unexpected imagery during the initial ideation phase, expanding the range of thought. However, they also cautioned that the high-quality image suggestions by AI could create a framework that imposes creative limitations. While AI increases the speed of idea generation and productivity, it may fall short in the depth of thought and relational considerations compared to traditional methods, warranting careful use. Experts predict that AI programs will play a significant supportive role in combining existing ideas, replacing them, or creating integrative concepts that require consideration of diverse values.

5-4. Additional Discussion

The general discussion revealed the following points: Depending on how language prompts are input, unexpected outcomes can arise, sometimes obstructing the thought process. Since the input is provided through language, it can be challenging to achieve precise ideation or thoughts due to the methodological differences between describing an image in words versus sketching it directly.

AI, while it enhances creativity, can also impose creative constraints. The suggestion of highly polished images may create a mental framework that limits creativity. Though AI accelerates idea generation and improves productivity, it requires caution, as the depth of thought and relational considerations may be less comprehensive than traditional methods. It was predicted that AI programs could serve as valuable assistants when integrating various ideas or considering multiple variables in the creation of holistic design outputs.

The relationship between design sketching, intuition, and creativity is multifaceted, underscoring the importance of sketching as a tool for idea conceptualization and as a medium for emotional expression. Insights from various studies suggest how sketching facilitates creativity and intuitive design processes. Sketching serves as a fundamental method for designers to

capture initial ideas, functioning as a form of "thinking through the hand" by transforming mental concepts into visual forms[25]. It stimulates a cycle of reinterpretation, enabling designers to explore new connections and directions, thereby enhancing creativity[26]. Research indicates that while sketching is essential for realizing design ideas, language prompts can complement the sketching process, suggesting a synergistic relationship between the two modalities[27].

6. Conclusion

This study concludes that AI tools positively impact design creativity, enhance work efficiency, and reduce revision time. Furthermore, the correlation between designers' skill proficiency and creativity scores provides insight into how the effective use of AI tools influences creativity.

However, this study has limitations in fully accounting for subjective factors such as designers' individual experiences, ease of use of the tools, and the complexity of tasks. Further research incorporating these elements is necessary.

The findings of this research provide a foundation for evaluating the potential of AI tools in the design field, suggesting that the advancement of AI will increasingly play a significant role in creative work environments.

Complementarity of AI and sketching: This study highlights the potential for AI systems and sketching to coexist and complement one another in the design process. While AI can assist in generating ideas and optimizing design, sketching enables designers to engage in creative thinking and problem-solving in a more intuitive manner. This research also offers various perspectives on how designers perceive the integration of AI tools into their workflow and whether sketching remains a fundamental step in the design process. Future research may involve a step-by-step comparison and analysis of traditional methods and AI-driven design methods, focusing on their usability and potential enhancements. Additionally, follow-up studies could divide experimental groups into those familiar with using AI and those without prior experience, enabling a detailed comparison of their specific reactions to the methodologies.

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