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The Transformation of the Design Thinking Process with AI Intervention

Focusing on Generative Artificial Intelligence and Large Language Models

AI 개입에 따른 디자인 씽킹 프로세스의 변화

생성형 인공지능 및 대형 언어 모델을 중심으로

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Abstract

The rapid evolution of Generative Artificial Intelligence with innovative technologies is making a significant impact within the Design Thinking Process. By using the ChatGPT-4 model from OpenAI, this study aims to evaluate the impact of Generative AI on design activities and establish a theoretical framework by reevaluating the Design Thinking Process. This paper conducts both quantitative and qualitative analyses. The quantitative analysis is performed using experimental surveys, word frequency, co-occurrence frequency, and CONCOR analysis, and the qualitative analysis is carried out through post-experiment interviews. The findings, derived from the comparisons of teams with and without prior Generative AI experience, highlight the positive impact of Generative AI on problem-solving, idea generation, and the convergence within UX design practices. Additionally, through the in-depth interviews with participants, it is possible to confirm the novelty and usability of Generative AI in the Design Thinking Process. The intervention of Generative AI in the Design Thinking Process promises substantial benefits for enhancing the roles of UX designers and a shift in traditional design thinking, by facilitating increased creativity and productivity in UX design tasks. There is a call for broader recognition and integration of these technologies to redefine the UX design process and its outcomes. For a more integrated approach within the UX design methodology, future research should aim to explore Generative AI's extensive applications and implications in design.

Keyword

Generative Artificial Intelligence(생성형 인공지능), Large Language Models(대규모 언어 모델), Design Thinking Process(디자인 사고 과정)

요약

생성형 인공 지능(Generative Artificial Intelligence)의 급속한 발전은 혁신적인 기술과 디자인 사고 프로세스(Design Thinking Process)에 큰 영향을 미치고 있다. 본 연구는 OpenAI의 ChatGPT-4을 이용하여 생성형 AI 개입이 디자인 사고 프로세스에 미치는 영향을 평가하고, 본 프로세스를 재평가하여 이론적 틀을 확립하고자 한다. 본 연구는 양적 및 질적 연구를 모두 수행하였으며, 양적 분석은 실험 조사, 단어 빈도, 동시 출현 빈도 및 CONCOR 분석을, 질적 분석은 실험 후 인터뷰를 통해 수행하였다. 피험자의 생성형 AI 경험 여부를 비교하여 실험 결과를 분석하였을 때, 생성형 AI가 문제 해결, 아이디어 생성 및 UX 디자인 실무 내 융합에 긍정적인 영향을 미친다는 것을 알 수 있었다. 또한, 심층 인터뷰를 통해 디자인 사고 프로세스에서 생성형 AI의 혁신성과 실무 내 적용 가능성을 확인할 수 있었다. 디자인 사고 프로세스 내 생성형 AI의 도입은 UX 디자인 작업 내 창의성과 생산성을 높이며 디자이너의 역할 강화 및 디자인 프로세스의 변화 가능성을 시사하였다. UX 방법론 내에 이러한 기술의 통합을 위해, 생성형 AI의 광범위한 적용 가능성 및 이에 대한 시사점을 탐색에 대한 후속 연구가 필요하다.

목차

1. Introduction

1-1. Background and objective of the research

Generative Artificial Intelligence (AI) has emerged as a transformative force across various industries, heralding a new era of design innovation. By leveraging user input to generate novel content, generative AI is not only expanding the realm of possibilities within design but also reshaping the role of User Experience (UX) designers. The rapid advancement of this technology is further evidenced by the increasing integration of generative AI tools in the UX design process[1].

Despite these technological advancements, the core challenges of design thinking—a methodical approach that requires a deep understanding, time, and resources—persist as designers strive to identify issues and build relevant solutions[2].

Previous research has highlighted the positive impacts of Generative AI on design outcomes and creativity[3]. However, there is a notable gap in the literature concerning its influence on the entire design thinking process. Specifically, the effects of generative AI on the critical phases of convergence and divergence within design thinking are under explored. Furthermore, there is a lack of comprehensive discussion on how the integration of generative AI is altering the conventional roles of UX designers, suggesting a gap in our understanding of the technology's broader implications on the design industry.

Addressing these observations, this study explores the previously unexamined effects of generative AI on UX design, focusing on enhancements in creativity and productivity, as well as transformations in the design thinking process. It will also examine shifts in UX designers' roles due to the integration of generative AI. By exploring these aspects, our research aims to contribute a nuanced understanding of generative AI's role in the evolution of UX design.

1) An M, Kang T, et al., A Study on the Evaluation of ChatGPT User Experience Design for Digital Transformation Management -Cross-utilization of OpenAI ChatGPT and Microsoft Bing ChatGPT, The Korean Society of Design Culture, 2023, Vol.29, No.2, pp.237-247.

2) Stige Å, Zamani D, Mikalef P, Zhu Y, Artificial intelligence (AI) for user experience (UX) design: a systematic literature review and future research agenda, Information Technology & People, 2023, p.29.

3) Lee S, Kim S, Framework for an Artificial Intelligence-Based Mobile App Design System, The Graduate School of Seoul National University, 2019.

We intend to investigate how generative AI tools not only enhance designers' creative capabilities by offering new ideation avenues but also streamline design processes through advanced problem-solving techniques.

Furthermore, this study will explore the evolving roles of UX designers as they adapt to and utilize generative AI technologies, potentially assuming new responsibilities such as prompt strategists or innovation facilitators. Ultimately, the study aims to illuminate the synergistic relationship between generative AI and UX design, highlighting its transformative impact on traditional design methodologies and its implications for designers' professional development and workflow optimization.

1-2. Research scope and methodology

This investigation aims to refine our understanding of the design thinking process by specifically focusing on its application within the realm of UX design, contrasting this with the background of traditional design methodologies. Through scholarly examination, we seek to establish a theoretical basis that highlights three pivotal areas. Initially, the study explores the traditional design thinking process, focusing on established frameworks and their significant roles in shaping design outcomes. This offers a foundational perspective from which the impact of new technologies on theses processes can be assessed. Building upon this, the study assesses the integration of generative AI tools in UX design workflows, scrutinizing how these advanced technologies have been employed to enhance or transform traditional practices. This includes an exploration of both the seamless integration and potential friction points encountered when melding generative AI with established UX design methodologies.

Finally, the investigation critically analyzes the broader impact of generative AI on the design thinking process, highlighting how these technologies are not merely auxiliary tools but pivotal in reshaping the stages of design thinking in UX. This analysis pays particular attention to the dual-edged nature of generative AI's influence, recognizing its capacity to significantly benefit the design process while also introducing new challenges that demand careful navigation. Through this comprehensive examination, the study aims to illuminate the evolving landscape of UX design in the age of generative AI, seeking to understand how designers can best leverage these technologies to enhance creativity, efficiency, and overall design quality.

The experimental component of our research primarily focuses on the practical exploration of generative AI's influence on UX design practices. Participants were categorized into two groups based on their prior experience with generative AI technologies: the Generative AI Experienced (AE team) and the Generative AI Non-Experienced (NE team). This bifurcation enabled a comparative analysis under identical experimental conditions, providing insights into how experience with generative AI may influence UX design outcomes. Throughout the experiment, which centered on developing a mobile UX app, data was systematically collected via design tasks, surveys, and in-depth interviews. These elements were collected to investigate the role of generative AI in enhancing creativity, productivity, and the overall efficiency of the UX design process.

The methodology extends beyond the experimental phase, incorporating a thorough analysis of the collected data to identify patterns, challenges, and opportunities presented by the integration of generative AI in UX design. The subsequent discussion phase explores the broader implications of our findings, emphasizing the evolving roles of UX designers in the face of advanced AI technologies. By examining the interaction between generative AI and design thinking in UX, this study strives to offer new insights into optimizing design workflows, enhancing creative outputs, and ultimately fostering a deeper integration of AI in design

practices.

2. Literature Review

2-1. Examination of the traditional design thinking process

Generative AI enhances the core principles of the design thinking process by segmenting user-centered solutions and offering creative resolutions, thereby reinforcing its effectiveness[4]. In this context, the aim of this study is to delve into how generative AI facilitates changes within the design thinking process, through an examination of the traditional thinking process's theoretical foundation[5].

According to Woo (2001), the design thinking process consists of three main stages[6]. Firstly, in the Concept phase, the most basic ideas or concepts about the design problem are formed. This begins at an abstract level and involves looking at the problem from a broad perspective through generalization. Secondly, the Transformation phase is where ideas that started from abstract concepts undergo a transformation process to become more concrete. This phase involves modifications and redefinitions that develop and expand the original concept in new directions. The final stage, the Object, results in the visualization of these transformed ideas into concrete forms, culminating in the actual design object through specialization. Woo further explains that the process of concretizing design can be divided into three major ideation stages: divergence, transformation, and convergence, emphasizing the need for a harmonious balance between convergent and divergent thinking according to the situation.

Jones (1992, p.64), in his book "Design Methods,"distinguished the design thinking process into three significant stages[7].

Firstly, Divergence is the stage where the design conditions and boundaries are expanded to set a broad exploration area, aiming to open up various possibilities and widen the scope of design solutions. The second stage, Transformation, forms patterns at the heart of the design process, including the pleasure, insights, and inspiration encountered during design execution. The final stage, Convergence, involves achieving consensus on objectives through a clear recognition of the problem, where various solutions are reviewed and repeatedly evaluated to derive the optimal solution.

Drawing on the foundational theories proposed by Woo (2001) and Jones (1992), this analysis sheds light on the intricate dynamics of design thinking. Their work elucidates the multifaceted stages of the design process, illustrating how each phase critically influences the ultimate design outcome. Through their scholarly contributions, Woo and Jones provide a comprehensive framework that underscores the importance of each step in the design thinking process, from ideation to realization, in shaping the final product. Building on these theoretical frameworks, this study investigates the potential changes generative AI could bring to the design thinking process. Unlike previous research focusing on design outcomes and enhancement of designers' creativity, this study examines the impact of generative AI on the divergent, convergent, and transformation stages of the

4) Weisz D, et al., Design Principles for Generative AI Applications, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, pp.1-22.

5) Thoring K, Huettemann S, Mueller M, The augmented designer: a research agenda for generative ai-enabled design, Proceedings of the Design Society, 2023, Vol.3, pp.3345-3354.

6) Woo H, A Computer Mediated Design Development System for Design Innovation, Archives of Design Research, 2001, pp.77-85.

7) Jones C, Design methods: seeds of human futures (2nd ed.), New York: John Wiley & Sons, 1992, p.9.

design thinking process and the subsequent changes in the role of UX designers.

2-2. Research on the support of generative AI for the UX design process

Up to this point, generative AI, which aims to foster creative thought, has often not fully addressed the comprehensive spectrum of design thinking, which includes divergent, convergent, and transformative processes. This gap presents a significant challenge for UX designers, who must input specific text to generate images that arise during their creative thinking process[8]. Koch et al. (2020) argue that tools designed to aid in creative thought should support all facets of design thinking, thereby assisting designers in developing new perspectives on their work. Moreover, while generative AI primarily provides support for UX tasks through graphic interfaces, Koch et al. (2020) reveal that "design thinking" is the most critical component in the real-world design process of UX designers[9]. Lu et al. (2020) have observed that most existing generative AI tools are tailored for creating simple, generic scenarios and design processes, which may not fully align with the complex, multi-directional, and staged planning required in the UX design process[10].

8) Brown A, et al., A Study on Generative Design Reasoning and Students' Divergent and Convergent Thinking, Journal of Mechanical Design, 2024, Vol.146, No.3, p.9.

9) Koch J, et al., Imagesense: An intelligent collaborative ideation tool to support diverse human-computer partnerships, Proceedings of the ACM on human-computer interaction, 2020, Vol.4, No.CSCW1, pp.1-27.

10) Lu Y, Zhang C, Zhang I, Li J, Bridging the Gap between UX Practitioners& work practices and AI-enabled design support tools, In CHI Conference on Human Factors in Computing Systems Extended Abstracts, 2022, pp.1-7.

During the design thinking process, designers are involved in both divergent and convergent thinking[11]. This study optimistically anticipates that generative AI will broaden the range of designers' thought processes and help in generating tangible solutions. In addition, with its capability to expand the boundaries of the design process and its rapid learning and adaptation abilities[12], generative AI is expected to offer significant assistance to UX designers in tackling the intricate challenges they face in their professional activities.

2-3. Influence of generative AI on the design thinking process

This research established a framework for a systematic examination of the interaction between the UX design process and generative AI, anchored in the traditional design thinking approach.

This framework is depicted in [Table 1]. The process stages of design thinking have been reevaluated, drawing from the foundational work of Jones (1992) and Woo (2001).

The analysis breaks down the essential stages of design thinking—Abstract Concept, Transformation, and Concrete Object—to anticipate the role of generative AI and its effect on the roles of UX designers within these stages. At the Abstract Concept phase, the focus is on defining the problem through research. Here, generative AI is expected to provide a broad range of data, facilitating the generation of varied ideas. As a result, UX designers are likely to be tasked with refining this plethora of information into a clear problem definition.

11) Frich J, Nouwens M, Halskov K, Dalsgaard P, How digital tools impact convergent and divergent thinking in design ideation, In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 2021, pp.1-11.

12) Verganti R, Vendraminelli L, Iansiti M, Innovation and design in the age of artificial intelligence, Journal of Product Innovation Management, 2020, Vol.37, No.3, pp.212-227.

In the Transformation phase, as text and images are generated iteratively, generative AI is predicted to encourage an environment conducive to divergent thinking, enabling designers to explore novel ideas. At the Concrete Object phase, generative AI is anticipated to aid in crafting tangible design outcomes. At this stage, designers are expected to navigate through a process of transformative thinking and selecting the most suitable solution.

[Table 1] Changes in the design process due to AI

Design Thinking Process	Abstract Concept	Transformation	Concrete Object
Keywords	Abstraction and Generalization (Understanding and Defining the Problem)	Pattern Generation (Personas and Storyboarding)	Visualization (Prototyping)
Types of Generative AI	Text-based Generative AI	Text and Image-based Generative AI	Image-based Generative AI
The Role of Generative AI	Divergence	Transformation (Convergence ↔ Divergence)	Divergence
Anticipated Role of UX Designers in the Context of Generative AI Intervention	Convergence	Divergence	Transformation (Convergence ↔Divergence)

3. Design and Conduct of the Experiment

3-1. Experimental design

This study embarked on an intricate exploration of generative AI's impact on the UX design thinking process and the subsequent roles of UX designers. Targeting seven UX designers with over five years of experience, we conducted design experiments, questionnaires, and in-depth interviews. These designers were familiar with the design thinking process, allowing for a nuanced investigation into the effects of generative AI [Table 2]. Participants were divided into two groups based on their experience with generative AI tools: three in the Generative AI Experienced (AE team) and four in the Generative AI Non-Experienced (NE team), ensuring a broad perspective on the experimental findings under identical conditions.

[Table 2] List of participants

Classification	Participant	Use of Generative AI	Company	Position	Experience
NE Team (Generative AI Non-Experienced)	Participant A	None	LG Electronics BS Design Research Institute, UX Design Team	Senior Researcher	More than 10 years
	Participant B		Blend	CEO	More than 10 years
	Participant C		Wemad Block	Associate	5 years
	Participant D		Nexon Korea Intelligence Labs	Deputy General Manager	10 years
AE Team (Generative AI Experienced)	Participant E	Many	Gentlepie	Pro	6 years
	Participant F		Ninefive	CEO	13 years
	Participant G		Runway	Product Designer	5 years

Participants engaged with the ChatGPT-4 model to conceptualize a scheduling application service for office workers aged 25-35, a choice aimed at aligning the experiment with a real-world context familiar to UX designers. This approach facilitated an efficient completion of design tasks within a set timeframe, focusing on mobile application service planning to closely

examine the impact of generative AI on various stages of the design thinking process and the roles of UX designers.

Allocating 50 minutes for the experiment, participants were directed to employ the GPT-4 model across three distinct tasks (Task A, Task B, and Task C), dedicating 10 minutes to each. These tasks were designed to probe into the convergent, divergent, and transformational thinking stages inherent in the design thinking process, as outlined in [Figure 1]. Subsequently, a structured survey featuring three questions per task (totaling nine questions) was conducted to assess whether generative AI notably enhanced productivity, creativity, and efficiency. This was complemented by individual interviews aiming to gather nuanced perspectives on the intervention of generative AI in UX design planning.

[Figure 1] Tasks based on convergent process, divergent process and transformational process

3-2. Execution and observation of the experiment

3-2-1. Guidelines for the experiment

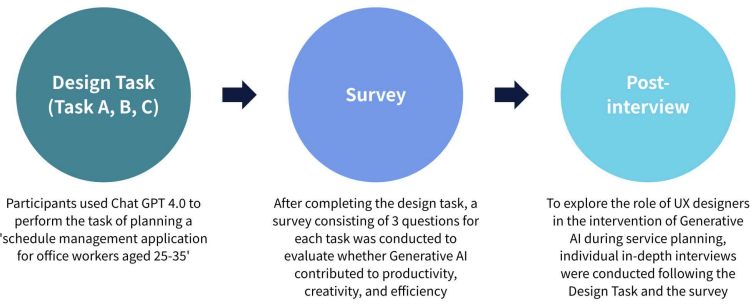
The structured experiment focused on creating a 'Schedule Management Mobile Application for Office Workers Aged 25-35', using the ChatGPT-4 model. This assessment incorporated divergent, convergent, and transformational thinking, guided by the "AI Tools in Design Thinking" framework proposed by Miller (2023)[13]. The design thinking stages—empathize, define and ideate, and prototype and test—were mapped onto specific tasks: defining the problem (Task A), creating personas and storyboards (Task B), and developing wireframes and prototypes (Task C). The experimental tasks aligned with the respective design thinking stages, offering a clear guide to the design tasks' structure and objectives.

This setup allowed for a holistic evaluation of generative AI's influence on different thinking modes within UX design, as illustrated in the research framework.

3-2-2. Conducting the experiment

Participants were strategically selected based on their significant experience level and a deep understanding of the design thinking process. This careful curation ensures that the individuals were well-equipped to handle the complexities of the experiment. Conducted via the Zoom platform to leverage ChatGPT-4's capabilities remotely, the experiment aimed for minimal intervention to authentically capture the designers' interactions with AI and facilitate an unbiased observation of their design thinking dynamics.

13) Miller D, Exploring the Impact of Artificial Intelligence language model ChatGPT on the User Experience, International Journal of Technology, Innovation and Management (IJTIM), 2023, Vol.3, No.1, pp.1-8.



[Figure 2] Experental stages

3-2-3. Conducting the experiment

The experimental framework was segmented into three main stages: design tasks, surveys, and post-experimental interviews [Figure 2]. Tasks A, B, and C were meticulously crafted to cover the spectrum of design thinking, from problem definition to prototyping. Despite using generative AI for both text and image outputs, the experiment revealed insightful differences in approach between the AE and NE teams [Figures 3 & 4], especially in tasks requiring textual prompts, as shown in [Tables 3 & 4]. This divergence provided a deeper understanding of how prior experience with generative AI influences UX designers' approach to design thinking and creativity.

[Figure 3] Personas and storyboards for Task B

[Figure 4] Wireframes and prototypes for Task C

[Table 3] Excerpts from prompts by the NE (Generative AI Non-Experienced) team

Participant	Design Task	Prompt Content
Participant A	Design Task A	Can you help me with my role as a service planner today?
		I'm going to plan a mobile app for schedule management for office workers aged 25-35.
		What are their most essential needs?
		Can you summarize their needs and preferences in a table?
		Can you summarize existing services targeting them and their problems in a table as well?
		Provide an example of the app.
	Design Task B	Let's plan an app that makes it easy to manage personal schedules in a typical calendar app.
		Create three personas who mainly use such an app.
		Generate images of the three representative personas.
		Change the images to Asian.
		Can you also create storyboards tailored to the purpose of using the app?
		Can you replace images for each scene in the storyboard created for each persona?
	Design Task C	Now, let's create wireframes and prototypes for the important features of our app.
		Let's sketch a wireframe for the home screen, and provide recommendations in images.
		Can you change the calendar view to a weekly view?
		Can you suggest more diverse wireframes?
		Draw the suggested wireframes as images
		Before making the prototype, let's design only the home screen.
		Can you style it with an IOS feel

[Table 4] Excerpts from prompts by the AE (Generative AI Experienced) team

Participant	Design Task	Prompt Content
Participant E	Design Task A	Hey, I'm currently planning a service, and I'm curious about the difficulties that office workers aged 25-35 encounter when managing their schedules. Do you have any insights?
		Do you think they might struggle with schedule management because they can't break down their tasks clearly?
		Also, could you tell me about any apps or services that recent graduates commonly use for schedule management?
		And can you provide the pros and cons of each service?
	Design Task B	Here are the characteristics for the persona: Age: 26 Gender: Female Major: Business Administration Personality: Enthusiastic and proactive but lacks attention to detail Occupation: Entry-level marketer at a cosmetics company
		Can you use the persona 'Kim Ji-eun' to create a daily work schedule within the workplace?
		It would be helpful if you could rewrite it in a storytelling format based on her concerns and personality traits.
		Please make her struggles with writing the marketing plan more specific.
	Design Task C	Basic Interface: Conversational interface Features: When the user inputs a schedule, the app prompts them to break it down into subtasks.
		Make it simpler and ensure that the conversation between the user and the app is more apparent.

4. Analysis of Experimental Results and Interviews

4-1. Analysis of experimental results

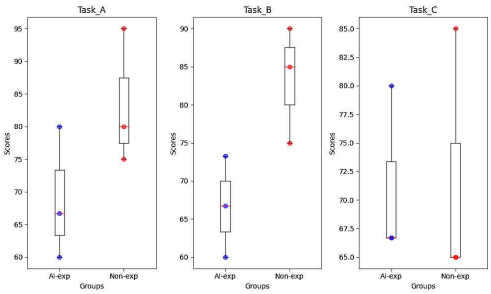
The analysis of the experiment, depicted in various figures, offers a nuanced understanding of generative AI's impact on the UX design process. Survey results indicate generally positive responses from both the AE (Generative AI Experienced) and NE (Generative AI Non-Experienced) teams, with average scores surpassing mid-values. However, a noticeable dip in satisfaction for Tasks B and C suggests a gap between the outcomes of generative AI and participants' expectations, a theme further investigated in subsequent interviews.

A detailed comparison of survey outcomes reveals that for Tasks A and B, the AE team's median values were notably higher by 8 and 10 percentage points, respectively, compared to the overall dataset. Task C, interestingly, showed no significant variance in average scores between the groups.

Contrastingly, the NE team recorded higher average and median values for Tasks A and B, exceeding the collective dataset by margins of 6 and 7 percentage points, respectively. Task C echoed the trend observed in the AE team, showing negligible differences.

An examination of the variations in survey results across all tasks and groups, uncovers that the NE team, despite lacking AI experience, expressed higher satisfaction levels than the AE team, particularly in Task C, albeit by a slim margin of 0.5 percentage points. The discrepancies between the groups for Tasks A and B are significant, potentially attributed to the AE team's prior experience with generative AI tools and their expectations thereof. Within each group, there was also noticeable variability between individual scores, reflecting a diverse range of interactions with the AI [Figure 5]. These variations were further explored through additional insights gathered in the

post-experiment interviews, as recorded in [Table 5].



[Figure 5] Survey results comparison between AE and NE teams

[Table 5] Summary of post-experiment interviews

Discussion Topic	Comprehensive Opinion
Task A Evaluation of Generative AI	"Providing sufficient quantity and content of text for consideration" (P=E, AE)(=C(NE), (F(AE)) "I think the research part will be the most helpful because it seems to provide insight into trends or contexts that remain constant" (P=G, AE)
Task B Evaluation of Generative AI	"The persona images used to be synthesized and edited by collecting images of ordinary people, but now, with artificial intelligence directly generating them, this part can really save time, and the generated images are also persuasive compared to the content of the persona." (P=B, NE) "But now, as soon as I describe the desired scene in text, it is immediately created, so this step and time have been greatly reduced." (P=A, NE)
Task C Evaluation of Generative AI	"It's nice to see the potential atmosphere before directly expressing what's in one's mind." (P=G, AE) "I also felt a little disappointed that they couldn't provide more creative responses to the core features of the schedule management app." (P=D, NE)(=C(NE)) "Rather than presenting ideas in a divergent direction or outside stereotypes, it felt more like showing summarized ideas at about two-thirds into the divergence process." (P=B, NE)
Improvements for Generative AI	"To advance user-centered design, some level of adjustment and human intervention is necessary." (P=D, NE)(=F, AE) "The quality of the output is expected to vary significantly depending on how the prompt is written." (P=B, NE)(=C(NE), D(NE), G(AE))
Assessment of the Role of UX Designers based on Generative AI	"The role of the designer may not change, but when it comes to visualizing actual services, it feels like there will be much more involvement needed, and generative AI will likely just provide assistance." (P=E, AE) "I wondered if the role of UI/UX designers might expand further into roles like prompt planners or prompt directors." (P=B, NE) "Because I felt that AI only throws out ideas, I think there should be at least one person to organize and converge them. This might be the role of the designer." (P=A, NE)(=C(NE))

4-2. Analysis of post-interviews

The post-experiment interviews provided deeper insights into the participants' experiences across the various tasks[14]. During Task A, it was discovered that the UX designers found the generative AI's capability to classify and sort data particularly useful.

This strength in the AI's divergent output during the convergent phase was seen as beneficial in handling large datasets, aligning with the goal to boost productivity through AI. Despite this, generative AI's role in creatively reconfiguring ideas received less favorable feedback, indicating a gap between its ability to process and present data and the designer's need for innovative data transformation[15]. This suggests a critical area for future development in generative AI, where enhanced data reconfiguration capabilities could provide greater value.

14) Bressler D, et al., How stem game design participants discuss their project goals and their success differently, In Advances in Quantitative Ethnography: Third International Conference, 2021, Vol.3, pp. 176-190.

15) Murray-Rust D, Lupetti L, Nicenboim I, Hoog D, Grasping AI: experiential exercises for designers, AI & SOCIETY, 2023, pp.1-21.

Task B focused on diversity in the divergent process and yielded high satisfaction, showcasing generative AI's ability to produce a variety of information, which is crucial for broadening design perspectives. However, a lack of genuinely novel ideas from the AI was noted, highlighting the limitation of AI's creative reach being bound by the input data it receives. This underlines the need for AI systems that can autonomously develop ideas that push beyond the initial context provided by users[16].

In Task C, satisfaction peaked around the transformational process, where generative AI assisted in refining and detailing wireframes and prototypes. However, participants inexperienced with AI faced difficulties in crafting effective prompts, affecting the quality of AI-generated outputs. This feedback emphasizes the importance of precise and elaborate prompts in shaping the AI's performance, pointing to potential improvements in AI prompt engineering that could lead to more beneficial design outcomes.

The interviews also revealed that while generative AI delivers logical and structured content, it may not be as effective in sparking the same level of creativity as human collaboration[17]. The potential for a synergistic effect through collective brainstorming with multiple designers was discussed, highlighting the need for further exploration into how generative AI and human designers can best collaborate to enhance creative outcomes.

16) Haefner N, Wincent J, Parida V, Gassmann O, Artificial intelligence and innovation management: A review, framework, and research agenda, Technological Forecasting and Social Change, 2021, Vol.162.

17) Rafner J, et al., Creativity in the age of generative AI, Nature Human Behaviour, 2023, Vol.7, No.11, pp.1836-1838.

4-3. Analysis of word frequency and relationships

In this paper, we conducted data mining analysis on post-interviews following the execution of design tasks A, B, and C by each participant. The analysis focused on the text inputted into GPT-4 and covered discussions on the participants' impressions after the design tasks, their thoughts on the outputs and visual materials generated by generative AI, and their views on the role of UX designers.

The following are the results of word frequency analysis and Word Clouds based on the input text data directly entered into GPT-4 by the participants for design tasks A, B, and C.

In Design Task A, words such as 'Do for,' 'Management,' and 'Function' showed the highest frequency. Task A involved using GPT-4 to converge on service and user needs, and the word frequency analysis indicates high occurrence of words related to problem definition, understanding, and specification in service planning [Figure 6].

In Design Task B, words like 'Storyboard,' 'Writing,' and 'Image' were most frequent. Task B involved using GPT-4 to create personas and storyboards through research, with word frequency analysis revealing high occurrences of words that aid in the divergent phase of the design process [Figure 7].

For Design Task C, words such as 'Do for,' 'Draw,' and 'Wireframe' appeared most frequently. Task C is a transitional stage where GPT-4 is used to establish services and features that contribute to the development of app prototypes. The results of the word frequency analysis indicate a high occurrence of words that support the transformation phase where both divergent and convergent processes are utilized [Figure 8].

[Figure 6] Word cloud of Task A

[Figure 7] Word cloud of Task B

[Figure 8] Word cloud of Task C

In the post-interview analysis of Design Tasks A, B, and C, the intensity level of co-occurring word frequency measurements indicates the frequency with which Words A and B appear together, and the category represents the ranking of these frequencies. Words that rank higher suggest a stronger semantic connection[18].

In post-interview Q1, which asked about impressions after the Design Task, the highest intensity levels of co-occurring word frequencies were found for 'Image and Thought,' 'User and Thought,' and 'User and Provide.' This suggests that when using generative AI, designers primarily seek methods to provide users with optimized design solutions, focusing on thoughts about images, thoughts about users, and information that can be provided to users [Table 6]. Post-interview Q2 inquired about participants' thoughts on the outputs or visual materials generated by generative AI. The co-occurring word frequencies with the highest intensity levels were 'Prompt and Outcome,' 'Prompt and Concrete,' and 'Prompt and Apply.' This indicates that the effectiveness of prompt engineering is closely linked to how specifically prompts are applied when using generative AI [Table 7]. Post-interview Q3 asked about the role of UX designers, and the highest intensity levels of co-occurring word frequencies were 'Do for and Thought,' 'Do for and Feeling,' and 'Do for and Actual.' This shows that UX designers use generative AI as a tool that help them express their thoughts and feelings [Table 8].

18) Zhao Y, Yin J, Zhang J, Wu L, Identifying the driving factors of word co-occurrence: a perspective of semantic relations, Scientometrics, 2023, Vol.128, No.12, pp.6471-6494.

[Table 6] Frequency of co-occurring words in Q1

Category	Word A	Word B	Intensity Level	Category	Word A	Word B	Intensity Level
1	Image	Thought	3	16	User	Content	2
2	User	Thought	3	17	User	Organization	2
3	User	Provide	3	18	User	Assist	2
4	Thought	Image	3	19	User	Function	2
5	Thought	User	3	20	User	Collect	2
6	Provide	User	3	21	User	Utilization	2
7	Image	User	2	22	User	Creativity	2
8	Image	Tendency	2	23	User	Clearness	2
9	Image	Assist	2	24	User	People	2
10	Image	Function	2	25	User	Adjustment	2
11	Image	Compare	2	26	User	Prompt	2
12	Image	Service	2	27	User	Technology	2
13	User	Image	2	28	Thought	Provide	2
14	User	Tendency	2	29	Thought	Tendency	2
15	User	Problem	2	30	Thought	Content	2

[Table 7] Frequency of co-occurring words in Q2

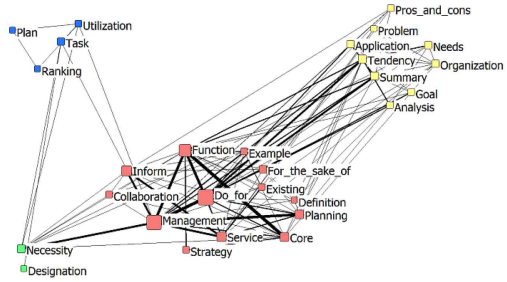
Category	Word A	Word B	Intensity Level	Category	Word A	Word B	Intensity Level
1	Prompt	Outcome	3	16	Function	Thoght	3
2	Prompt	Concrete	3	17	Prompt	Thoght	2
3	Prompt	Apply	3	18	Prompt	Process	2
4	Thought	Function	3	19	Prompt	Regrettable	2
5	Outcome	Prompt	3	20	Prompt	Provide	2
6	Outcome	Concrete	3	21	Prompt	Content	2
7	Outcome	Apply	3	22	Prompt	Text	2
8	Regrettable	Text	3	23	Prompt	Analysis	2
9	Concrete	Prompt	3	24	Prompt	User	2
10	Concrete	Outcome	3	25	Prompt	Function	2
11	Concrete	Apply	3	26	Prompt	Request	2
12	Text	Regrettable	3	27	Prompt	Actual	2
13	Apply	Prompt	3	28	Prompt	Creativity	2
14	Apply	Outcome	3	29	Prompt	Example	2
15	Apply	Concrete	3	30	Prompt	Style	2

[Table 8] Frequency of co-occurring words in Q3

Category	Word A	Word B	Intensity Level	Category	Word A	Word B	Intensity Level
1	Do_for	Thought	5	16	Do_for	Content	2
2	Thought	Do_for	5	17	Do_for	Organization	2
3	Do_for	Feeling	3	18	Do_for	Materials	2
4	Do_for	Actual	3	19	User	Provide	2
5	Do_for	Help	3	20	User	Importance	2
6	Do_for	Good	3	21	Thought	Use	2
7	Thought	Feeling	3	22	Thought	Content	2
8	Thought	Actual	3	23	Thought	Organization	2
9	Feeling	Do_for	3	24	Thought	Materials	2
10	Feeling	Thought	3	25	Thought	Help	2
11	Actual	Do_for	3	26	Thought	Good	2
12	Actual	Thought	3	27	Provide	User	2
13	Help	Do_for	3	28	Provide	Importance	2
14	Good	Do_for	3	29	Feeling	Use	2
15	Do_for	Use	2	30	Feeling	Actual	2

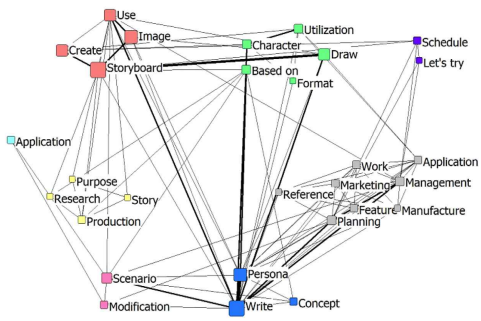
During the experiment, participants entered input text data into GPT-4 for design tasks A, B, and C, which were then analyzed using CONCOR analysis. The color and thickness of the lines in the analysis represent the strength of the relationships between nodes, with thicker lines and central nodes indicating stronger or more frequent connections.

Task A involves converging processes such as problem definition, understanding, and specification for service planning. In the CONCOR analysis of Task A, the blue group, which includes terms like Ranking, Task, and Utilization, represents the initial stages of service planning, such as planning establishment and user needs analysis. In UX design, this stage is crucial for setting the project's scope and objectives and defining related tasks and roles. The red group, containing terms like Do for, Management, and Function, appears to represent essential collaboration, management, and strategy development in the service planning process. It signifies how UX designers and generative AI can collaborate effectively, manage the design process, and develop strategies to enhance user experience. The yellow group, which includes Summary, Goal, and Analysis, has the strongest relationship with the red group and deals with more abstract and conceptual aspects of service planning, such as problem-solving, identifying user needs, setting organizational goals, and analysis. UX designers use generative AI to understand user needs and problems and, based on this understanding, set specific design objectives [Figure 9].



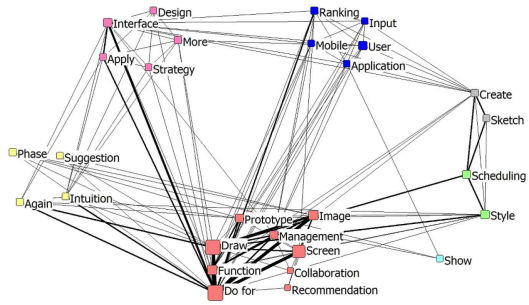
[Figure 9] Task A concor analysis

Task B involves a divergent process based on research to create personas and storyboards. The CONCOR analysis for Task B shows that the blue group, which includes Persona, Write, and Concept, focuses on the creation of personas and definition of concepts. In UX design, generative AI is used to create virtual characters that represent user characteristics and needs, and it is employed in the early stages of design to understand user requirements. The green group, containing Character, Based on, and Format, focuses on the materials and formats used in the design process and how they are utilized, holding the strongest relationship with the blue group's concept definition process. The red group, including Create, Use, and Storyboard, represents the creative processes necessary to materialize ideas, such as creating storyboards, using tools, and generating images. UX designers use AI to visually organize design ideas and concretize user experiences through scenarios [Figure 10].



[Figure 10] Task B concor analysis

Task C is a transformation process that involves establishing services and features to derive prototypes. The CONCOR analysis for Task C shows that the red group, which includes Prototype, Image, and Draw, represents various activities involved in the prototype creation process. UX designers use generative AI to draw prototypes, create images, and define functions, thereby concretizing the screen design. The pink group, containing Design, Interface, and Apply, has the strongest relationship with the red group and involves higher-level decisions related to design concretization, interface design, and application. This represents strategic decision-making processes that encompass overall project direction and the application of design. The blue group, including Mobile, User, and Application, focuses on elements related to users and mobile applications. It suggests that UX designers' inputs and preferences in generative AI are used as critical data in prototype design, playing a significant role in establishing service functionalities centered around user experience [Figure 11].



[Figure 11] Task C concor analysis

4-4. The roles of UX designers and generative AI

Integrating the survey results with post-interview feedback enabled a refined understanding of AI's role within UX design, as illustrated in [Figure 12].

In Task A, participants notably benefited from generative AI's capability to group or classify

ideas, as evidenced by significantly high scores in survey results. Feedback included perspectives such as, "AI is unlikely to replace designers but could aid in quicker data retrieval or enhance the efficiency of designers' tasks," suggesting generative AI's supportive role in time-intensive areas like problem definition, understanding, and specification. This leads to the conclusion that generative AI acts as an auxiliary tool in Task A, enhancing designers' productivity.

Task B feedback highlighted generative AI's effectiveness in producing a variety of information or perspectives during the divergent phase. Survey responses and subsequent post-interview interpretations confirmed the value of "creating diverse perspectives." Comments like, "Collaboration among people can spur fun and unexpected ideas, whereas artificial intelligence tends to provide logical content, challenging its ability to generate completely new ideas," indicated that generative AI served as an auxiliary tool in Task B. It synthesized designers' input prompts into a cohesive visual representation. Despite the challenge of deviating from the input data's context limiting creative ideation, designer intervention in processing the provided data and the redesign of visual outputs reduced time spent on this stage, leading to efficiency gains through enhanced convergent and divergent thinking.

In Task C, it was observed that participants greatly benefited from the process of selecting and elaborating on the results provided by generative AI, thereby redefining its role from merely an auxiliary tool to a collaborative partner. Insights revealed, "The construction of prompts can systematically facilitate both divergent and convergent processes from the designer's viewpoint. The collaboration between a designer and AI, given their distinct expertise, is likely to vary the approaches and styles in data collection and analysis, which could, in turn, foster the ideation process." This indicates that varied prompt inputs might enhance ideation facilitated by generative AI, transforming it into a collaborative force. Despite some opinions that its functionality did not meet the high expectations set against other image generation AIs, a widespread readiness among participants to engage with it more actively if enhancements were made—coupled with observations like "The problem is with the DALL-E 3 tool integrated into ChatGPT-4" and "Would be keen to use it more if it were improved"—suggests that the lower scores for Task C originated from anticipations linked to ChatGPT-4 and aspects related to prompt formulation. Given the active engagement between participants and generative AI in this task, along with the enthusiastic feedback, it became evident that generative AI acted as a collaborative partner in this phase, facilitating designers in experiencing transformation through continuous divergence and convergence[19].

19) Wang S, et al., RoomDreaming: Generative-AI Approach to Facilitating Iterative, Preliminary Interior Design Exploration, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, pp.1-20.

[Figure 12] Roles of generative AI across tasks

5. Conclusion and Recommendations

5-1. Significance of the study

This investigation systematically explored the integration of generative AI within the design thinking process, especially focusing on the nuances of designer roles. By segmenting design tasks, the study dissected and analyzed the impact of generative AI at different stages of the design thinking process, providing insights into how UX designers can evolve their roles and become more proficient in using generative AI as both prompt strategists and designers[20].

In the convergent phase of Task A, participants successfully utilized AI to organize and process large data sets, expediting the presentation of various solutions.

Nonetheless, the necessity for user refinement of AI-generated outcomes and a deeper understanding of prompt formulation was evident, with a tendency for generative AI to lead to abstract results. Despite these challenges, AI's significant impact on productivity was clear.

Task B's divergent phase illustrated how generative AI can streamline the creation of personas and storyboards, which are traditionally time-consuming tasks for UX designers. The collaborative process between the designers and AI in iteratively refining prompts and generating outcomes proved efficient and suggested that designers could take on more strategic roles, potentially as prompt directors, to enhance productivity and innovation.

Task C highlighted a disparity between expectations and the generative AI's output regarding wireframes, with results often being more abstract than desired.

It was noted that ChatGPT-4's image generation capabilities are not yet on par with other AI technologies like MidJourney or Stable Diffusion, which affected the quality of the images generated. Nevertheless, the role of generative AI in fostering new design perspectives and aiding the initial stages of wireframe development was recognized. The variability in prompt crafting underscores the need for specialized training to maximize the efficacy of generative AI in professional settings.

This investigation clarified the shift in UX designers' roles with the incorporation of generative AI and articulated its role within the design thinking framework[21].

It introduces novel viewpoints on the traditional design thinking approach in the dynamically evolving design industry due to generative AI interventions which are anticipated to significantly contribute to the field of design. The outcomes further expand understanding of the designer's role in a wider socio-cultural context, offer directions for forthcoming UX design education, and establish foundational principles for employing generative AI in real-world design thinking processes.

5-2. Limitations and recommendations for further research

This study has a limitation due to small number of participants, which restricts the extrapolation of its results. This highlights the necessity for future studies that encompass a more extensive group of participants. In addition, differing levels of familiarity with ChatGPT-4 among participants led to individual variations in prompt input, which might have influenced both the conduct and the results of the experiment.

20) Li J, et al., User experience design professionals' perceptions of generative artificial intelligence, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, pp.1-18.

21) Zdanowska S, Taylor S, A study of UX practitioners roles in designing real-world, enterprise ML systems, In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems, 2022, No.531, pp.1-15.

Lastly, the lack of participant diversity might have narrowed the range of designer perspectives and experiences captured, pointing to the need for broader studies that include designers from varied backgrounds.

References

1. Jones C, Design methods: seeds of human futures (2nd ed.), New York: John Wiley & Sons, 1992.
2. An M, Kang T, et al., A Study on the Evaluation of ChatGPT User Experience Design for Digital Transformation Management -Cross-utilization of OpenAI ChatGPT and Microsoft Bing ChatGPT, The Korean Society of Design Culture, 2023, Vol.29, No.2.
3. Bressler D, et al., How stem game design participants discuss their project goals and their success differently, In Advances in Quantitative Ethnography: Third International Conference, 2021, Vol.3.
4. Brown A, et al., A Study on Generative Design Reasoning and Students' Divergent and Convergent Thinking, Journal of Mechanical Design, 2024, Vol.146, No.3.
5. Frich J, Nouwens M, Halskov K, Dalsgaard P, How digital tools impact convergent and divergent thinking in design ideation, In Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 2021, No.431.
6. Haefner N, Wincent J, Parida V, Gassmann O, Artificial intelligence and innovation management: A review, framework, and research agenda, Technological Forecasting and Social Change, 2021, Vol.162.
7. Koch J, et al., Imagesense: An intelligent collaborative ideation tool to support diverse human-computer partnerships, Proceedings of the ACM on human-computer interaction, 2020, Vol.4, No.CSCW1.
8. Li J, et al., User experience design professionals' perceptions of generative artificial intelligence, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, No.381.
9. Lu Y, Zhang C, Zhang I, Li J, Bridging the Gap between UX Practitioners& work practices and AI-enabled design support tools, In CHI Conference on Human Factors in Computing Systems Extended Abstracts, 2022, No.268.
10. Miller D, Exploring the Impact of Artificial Intelligence language model ChatGPT on the User Experience, International Journal of Technology, Innovation and Management (IJTIM), 2023, Vol.3, No.1.
11. Murray-Rust D, Lupetti L, Nicenboim I, Hoog D, Grasping AI: experiential exercises for designers, AI & SOCIETY, 2023.
12. Rafner J, et al., Creativity in the age of generative AI, Nature Human Behaviour, 2023, Vol.7, No.11.
13. Stige Å, Zamani D, Mikalef P, Zhu Y, Artificial intelligence (AI) for user experience (UX) design: a systematic literature review and future research agenda, Information Technology & People, 2023.
14. Thoring K, Huettemann S, Mueller M, The augmented designer: a research agenda for generative ai-enabled design, Proceedings of the Design Society, 2023, Vol.3.
15. Verganti R, Vendraminelli L, Iansiti M, Innovation and design in the age of artificial intelligence, Journal of Product Innovation Management, 2020, Vol.37, No.3.
16. Wang S, et al., RoomDreaming: Generative-AI Approach to Facilitating Iterative, Preliminary Interior Design

Exploration, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, No.379.

17. Weisz D, et al., Design Principles for Generative AI Applications, In Proceedings of the CHI Conference on Human Factors in Computing Systems, 2024, No.378.

18. Woo H, A Computer Mediated Design Development System for Design Innovation, Archives of Design Research, 2001.

19. Zdanowska S, Taylor S, A study of UX practitioners roles in designing real-world, enterprise ML systems, In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems, 2022, No.531.

20. Zhao Y, Yin J, Zhang J, Wu L, Identifying the driving factors of word co-occurrence: a perspective of semantic relations, Scientometrics, 2023, Vol.128, No.12.

21. Lee S, Kim S, Framework for an Artificial Intelligence-Based Mobile App Design System, The Graduate School of Seoul National University, 2019.