Exploring the Integration of Generative AI in User-Centered Design

A Case Study with Design Students

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This paper investigates the integration of generative AI tools within the User-Centered Design (UCD) framework, focusing on a case study involving design students from the University of Applied Sciences in Mainz. The study evaluates the benefits and limitations of AI tools in supporting the design process. The students developed an interactive solution using various AI tools throughout the UCD stages, including problem definition, ideation, prototyping, and user feedback. Findings indicate that while AI tools can aid in data analysis and idea generation, they often explore problems at a superficial level, making it challenging to achieve a deep understanding of the problem-solution interplay. Furthermore, the linear interaction mode of the AI tools used in this course and their limited collaborative capabilities were a major drawback.. The study highlights the importance of balancing AI use with human intuition and creativity to achieve more nuanced and effective design outcomes. Future research should focus on enhancing AI's collaborative features and context awareness to better integrate into the design process.

CCS CONCEPTS • Interaction design process and methods

Additional Keywords and Phrases: Artificial Intelligence and Design, Generative, AI, User Centered Design, AI Tools, Design Process

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1 INTRODUCTION

In recent years, generative artificial intelligence (AI) tools have gained significant prominence, particularly in the field of design [1]. However, the majority of discussions surrounding generative AI in design tend to concentrate on image generation. This narrow focus fails to acknowledge the broader spectrum of tasks involved in the design process, particularly in the context of user-centred design (UCD) [2]. The UCD framework places a strong emphasis on the understanding of user needs, the generation of ideas and requirements, the prototyping of concrete solutions, and the incorporation of user feedback at various stages [2]. This comprehensive approach necessitates careful consideration when integrating generative AI into these diverse tasks.

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To investigate the potential applications of AI tools in the development of interactive solutions and assess their advantages and limitations, a case study was conducted with design students from the University of Applied Sciences in Mainz. To achieve this, students developed an interactive solution, which was created using AI tools throughout the UCD process.

This raises the question of the extent to which AI tools can support designers, particularly those at the beginners This paper begins by presenting a theoretical perspective on the design process, examining the cognitive processes involved and the competencies essential for designers. Subsequently, the setup of the use case is briefly described, accompanied by some initial insights into the students' experiences. By analyzing the outcomes, it is possible to identify where AI can enhance or hinder the design process and to gain insights into the potential and limitations of AI tools in both professional and educational contexts.

2 THEORETICAL BACKGROUND

While we often admire designers for their solutions, it is their ability to identify the right problems that often distinguishes great design from merely adequate or poor design [3]. Under this perspective, design is not just about finding "the optimal solution to the given problem"; rather is a creative and exploratory process aiming for solutions beyond the obvious problem. In design, problems and solutions are closely intertwined. Designers navigate through the problem space by making small steps into the solution space and positive steps that deepen their understanding [4]. When they can no longer maintain a positive sequence, they move into a new problem space. During the design process, emergent aspects come into play, where relevant features appear in preliminary concepts, suggesting how the evolving solution might adapt to the developing problem. It means, the design challenge is just the starting point for a journey of discovery, focusing on uncovering something new rather than achieving what is already known [3].

Experienced designers have highly developed, tacit cognitive skills that are deeply embedded in their work. These "intuitive skills" are either inherent or developed through education and extensive practice [3]. These responses come from a wealth of experience with both appropriate and inappropriate results in various situations. This "intuitive thinking" can be correct in a deeper sense, as it is not based on conventional logic. Designers think abductive, involving the formation of hypotheses from observations [5]. Abductive reasoning allows designers to suggest what might be, bridging gaps and making sense of complex situations.

Techniques like sketches, prototypes, mock-ups, and scenarios enable designers to explore future situations and develop appropriate solutions [3, 6]. Due to cognitive limits on the complexity that can be processed internally, designers must interact with external representations. Sketching provides a temporary external memory for preliminary ideas and supports the dialogue between problem and solution. Designers learn to think through sketching, transforming abstract client and user requirements into concrete patterns. This skill, known as graphicacy, is as essential as literacy and numeracy [7]. Thinking and drawing often happen in parallel, with sketches serving as a record of the evolving solution.

Designers engage in parallel cognitive processes relevant to the same task, balancing multiple ideas before converging on a solution. The ability to design a complex web of ideas, while eventually making concrete decisions, highlights the evolving nature of design [8]. This activity in design is so called synthesis, a process for which there is no universally accepted reasoning method. The externalization and graphical representation of design solution support a social practice within designer and other stakeholders involved in the design process, often taking place in open studio environments where work is visible and subject to critique [9]. This public construction of design fosters a culture of feedback and shared learning.

3 METHOD: USE CASE

To evaluate the use of AI tools within the User-Centered Design (UCD) framework, a use case method was employed. The study involved 10 students from the University of Applied Sciences in Mainz, all of whom were in their 4th to 7th semester of the Bachelor Communication Design and had prior experience with UCD. The students worked in pairs, making up five groups in total. The objective for the students was to develop an interactive solution to help fellows become more organized during the semester. They began with the following problem statement: "Design students are often disorganized and need support to improve their organization."

Each group utilized AI tools throughout different phases of the design process, including the analysis, generation of design suggestions, and simulation of user interactions. The process included several key tasks:

- **Understand and describe the context:** Students started by defining the problem and conducting user research to understand the organizational challenges faced by the fellow design students.
- **Specify user requirements:** Based on the research findings, students brainstormed and developed initial user stories for their interactive solutions.
- **Develop a design solution:** The groups created prototypes of their solutions by creating wireframes, mock-ups, and interactive elements.
- **Evaluate the design solution:** The prototypes were tested for usability, especially the emotional reaction of the users when testing the concept of the solution.

Throughout the course (14 weeks), the students documented their experiences in a weekly protocol, noting where AI tools were particularly helpful and where they encountered limitations. This documentation provided valuable insights into the effectiveness of AI tools in supporting beginner designers in a structured design process.

4 RESULTS

The students tested various AI tools while performing tasks related to the development of their interactive solution. These tools were utilized in specific phases of the UCD process, as illustrated in Figure 1. Some tools were roughly tested, while others were used for the design process. The key findings of these tools are detailed below.

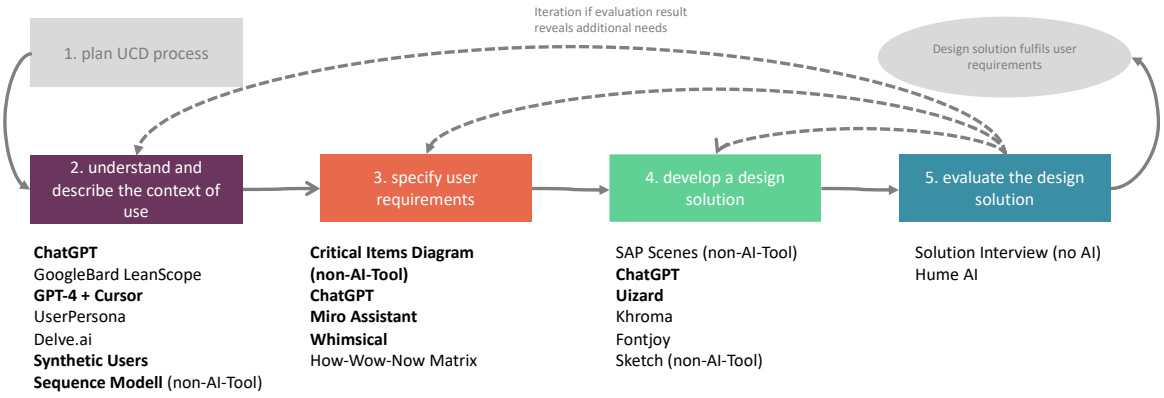


Figure 1. List of tools used in the User Centered Design Process

ChatGPT (https://openai.com/chatgpt/)
ChatGPT was primarily used in phase 2 to help students explore the problem space and understand user needs, problems, and wishes. Students often asked ChatGPT to act as a design student with organizational issues. This interaction provided a broad overview of tasks and potential problems, but the information was often context-independent and generic. Consequently, students had to engage in lengthy follow-ups to obtain more detailed and specific insights. Therefore, the extended chat interactions made it difficult to process and synthesize useful information into clear insights.

Cursor (https://www.cursor.com/)
Cursor is an AI code editor that integrates a text editor with GPT. This tool enabled better processing and combination of the information obtained from ChatGPT and supports the transformation of information into coherent insights. Using the cursor, students were able to seamlessly copy, combine and rearrange parts of the chat responses. This integration allowed a more meaningful and personalized processing of the information, leading to a better understanding of users' needs and problems.

Synthetic Users (https://www.syntheticusers.com/)
Synthetic Users are AI-generated personas designed to replicate human user behavior for research, testing, and product development. These personas allowed students to interview different representatives of the target group. Although the personas could be edited to better match the context, the information provided remained generic. The students found it challenging to gain deeper insights into real problems through these interactions, often perceiving the generated personas as stereotypical.

Sequence Model (non AI-Tool)
The students encountered challenges in gaining a deeper understanding of the problem using AI tools for user research. To address this, a Contextual Design tool known as the Sequence Model was incorporated into the process [10]. The Sequence Model outlines the detailed steps required to accomplish each task relevant to the work, showcasing different strategies, intents, goals, and the obstacles encountered. By analyzing the workflow over a semester-long period, the students were able to identify more nuanced problems and gain a deeper understanding of the design task. This analysis allowed them to decompose the initial design challenge into more context-specific issues. While the AI tools primarily identified organizational problems, such as missing to-do lists and plans, the students discovered that the primary issue was overlapping deadlines across all courses, unnegotiable submission deadlines. Additionally, the simultaneous pacing of projects across courses led to periods of high intensity and stress. Most of these issues could not be effectively addressed through to-do lists or improved personal management alone; instead, they required a comprehensive approach to course progression and curriculum design. This deeper understanding highlighted the limitations of AI tools in capturing the full scope of complex, context-dependent problems, underscoring the need for human insight in the design process.

Critical Items Diagramm (non AI-Tool)
Upon attaining a more profound comprehension of the issue at hand, the students employed the Critical Items Diagram to devise a new design challenge [11]. The tool facilitated the processing of the results from the understanding phase, the identification of key elements, and the agreement on essential project components by the

team. Furthermore, the Critical Items Diagram facilitated the synthesis of these elements into a How-Might-We question. Unfortunately, the new design challenge formulated using this method proved to be again too abstract for subsequent steps. The overly broad questions proved to be ineffective in guiding the design process. In contrast, the more specific problems identified using the Sequence Model, such as overlapping deadlines and course progression issues, led to the generation of more actionable and context-specific ideas in the following stages. This experience demonstrated the significance of defining design challenges with sufficient specificity, particularly when using AI tools.

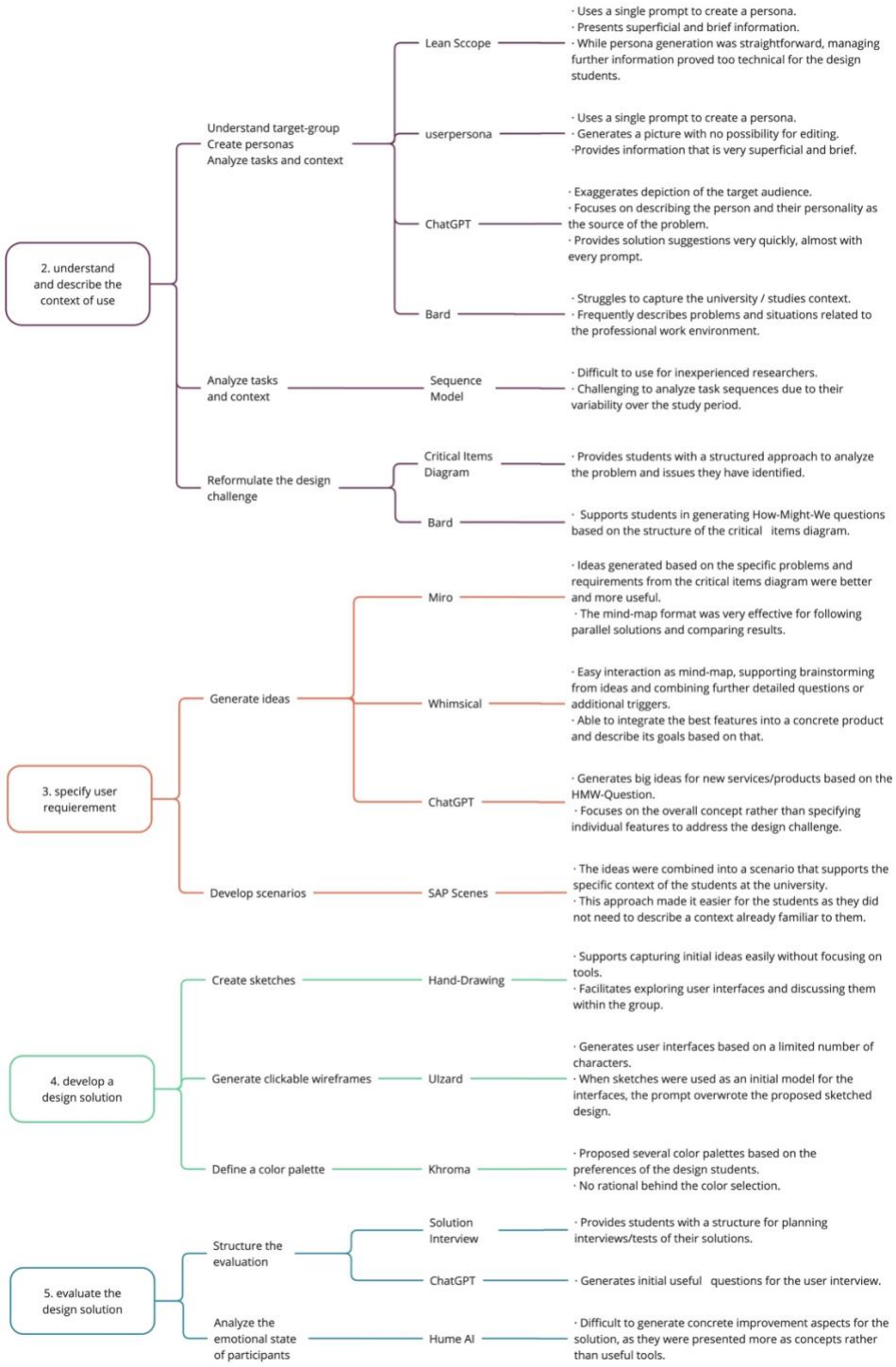
Whimsical (https://whimsical.com/)
Whimsical is a web application designed for team collaboration in the design process. It supports tasks such as ideation, brainstorming, and creation of sitemaps or user flows through functions like mind maps and flowcharts. Whimsical, powered by GPT-4, provided a more natural and interactive way to process information. The mind map function, in particular, allowed students to interact with chat results more flexibly, generating ideas and requirements for the new solution.

Miro Assist (https://miro.com/de/assist/)
Miro Assist is a feature available in miro digital whiteboard that supports the generation mind maps and notes, and also group them according to specific terms or topics. The students used Miro Assist for problem analysis and idea generation for their new interactive solution. By creating sticky notes and diagrams, students found it easier to delve deeper into the problem space, especially due to their interactive capabilities, as already mentioned in the use of Whimsical.

UIzard (https://uizard.io/)
Uizard is a rapid prototyping tool designed to transform wireframes into high-fidelity prototypes automatically. It utilizes computer vision and machine learning algorithms to convert hand-drawn sketch images into detailed mockups. The students explored Uizard to generate prototypes based on prompts and images captured from their paper sketches. The prompt-based interface used in Uizard allowed for the construction of UI designs according to predefined patterns, covering some features specified in the previous phase of the process. However, the prompts allowed in Uizard were limited to 300 characters, resulting in UI and flow designs that were based on standard design patterns and did not fully incorporate all the detailed features and aspects specified by the students. The Sketch-to-UI feature also produced designs that heavily relied on standard design patterns, limiting the uniqueness and customization of the prototypes.

Figure 2 offers a detailed overview of the specific tools employed by Group 3, highlighting their concrete applications, issues encountered, and documented protocols along with result analyses. This comprehensive account provides an in-depth examination of how each tool influenced the design process, showcasing both the beneficial and detrimental impacts on the tasks performed. It allows for a clearer understanding of the tools' effectiveness and limitations within the context of the User-Centered Design framework. Furthermore, the table underscores the variability in tool performance across different design stages, revealing critical insights into when and how certain tools can be most effectively utilized. By documenting these interactions, the analysis also emphasizes the importance of selecting appropriate tools tailored to specific design tasks.

Figure 2: Use Case Group 3 | Tasks, Tools and found Issues



5 DISCUSSION AND CONCLUSIONS

This study explored the use of generative AI tools within the User-Centered Design (UCD) framework by analyzing the experiences of design students. Several key insights were obtained, highlighting both the benefits and limitations of these tools in supporting the design process.

As perceived by students, generative AI tends to explore problems only at a surface level, making it challenging to achieve a deeper understanding and connection to the problem. This limitation is particularly evident in interactions conducted through chat interfaces, which struggle to maintain consistent discovery sequences and often result in digressions. Additionally, it requires students to engage in lengthy interactions to obtain useful information. This led to an overwhelming amount of information that was difficult to synthesize into clear insights.

The AI tools did not significantly leverage the students' intuition and experience. The reliance on AI's input can hinder the depth of problem-solving interplay, as designers' cognitive engagement is reduced. While AI provides valuable suggestions, it is essential to balance this with human intuition and experience to achieve more nuanced and effective design solutions. Tools like Cursor, which integrates a text editor with GPT, helped improve this process by allowing students to organize and combine information more effectively. However, the primary creative insights still depended on the students' own thinking.

Synthetic Users and the Sequence Model provided richer contextual understanding but still faced challenges. While Synthetic Users offered a way to simulate interactions with target users, the generated personas were often perceived as too generic and stereotypical. Non-AI tools like the Sequence Model and Critical Items Diagram allowed students to develop a more specific and contextualized understanding of the problems, leading to more effective problem identification and solution generation.

Interactions with AI, particularly through chat, tend to be linear, making it difficult to pursue parallel ideas and maintain a holistic view of the problem space. This linearity contrasts with the often non-linear and iterative nature of traditional design thinking, which relies on simultaneous exploration of multiple ideas and solutions. Visual and interactive tools like Whimsical and Miro Assist were more effective in supporting the students' design thinking, enabling them to visualize and organize their ideas in a flexible manner.

Generative AI uses abductive reasoning, similar to human designers, to form hypotheses and suggest potential solutions. However, the AI's reasoning process is based on a general reservoir of experience rather than specific situational knowledge. This generality can limit the relevance and specificity of AI-generated solutions. Additionally, developing a personal view of the problem/solution space with AI is labor-intensive, and the designer's unique perspective can never be fully captured by the AI.

Overall, the study highlights both the potential and limitations of generative AI tools in the design process. While these tools can support specific tasks during the design process, they currently fall short in facilitating deep problem exploration and leveraging human creativity to its fullest extent. Effective design solutions still rely heavily on human intuition and creativity, with AI serving primarily as a supplementary tool.

Future research should focus on enhancing the collaborative capabilities of AI tools, making them more interactive and situationally aware. Integrating AI tools that better support parallel cognitive processes and deeper contextual understanding will be essential. Additionally, improving the ability of AI tools to provide detailed, context-specific feedback can further enhance their utility in both educational and professional design settings. By addressing these areas, we can better leverage the strengths of AI while mitigating its limitations, ultimately fostering a more effective and balanced integration of AI in the design process. A balanced approach that combines the strengths of AI with human intuition and experience is essential for achieving optimal design outcomes.

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