Understanding Fashion Designers' Behavior Using Generative AI for Early-Stage Concept Ideation and Revision

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Abstract

Background   Generative AI has emerged as a powerful tool in fashion design, supporting activities such as ideation, sketching, and creativity enhancement. This study explores how commercial generative AI tools like Bing, Midjourney, and DALL-E can augment the creative processes of professional fashion designers during the early stages of concept ideation and revision.

Methods   A mixed-methods approach was employed, involving a pilot study, sketch experiment interviews, and a focus group discussion. 19 participants, including design students and professionals, used AI tools Midjourney and DALL-E for concept ideation and revision. Data were analyzed using thematic analysis, focusing on understanding designers' behavior and decision-making processes while using generative AI tools.

Results   Generative AI tools significantly enhanced the early stages of fashion design by providing diverse and rapid visual stimuli. Designers interacted with AI tools through text prompts, refining hand-drawn sketches, and enhancing digital sketches, which facilitated creativity and decision-making. Challenges identified included biases in AI outputs, intellectual property concerns, and usability issues.

Conclusions   The study highlights the potential of generative AI to enhance the fashion design process by providing diverse visual stimuli and accelerating concept ideation and revision. The study identifies key challenges such as biases, intellectual property concerns, and gaps between designer intentions and AI realizations. Future research should explore a broader range of AI tools, long-term impacts, and ethical implications, underscoring AI's role in augmenting and co-creating, rather than replacing, human creativity in fashion design.

Keywords   Generative AI, Fashion, Design, Human-AI Co-Creation, Concept Design

1. Introduction

The integration of intelligent tools into design processes is becoming increasingly common, supporting activities such as ideation, sketching, and fostering creativity (Tholander & Jonsson, 2023). Tools such as ChatGPT[1] enable natural language interactions with AI, significantly impacting various creative domains (Kirmani, 2022). Text-to-image generators like DALL-E[2], Midjourney[3], and Stable Diffusion[4] have revolutionized the creation of realistic images and artworks from textual descriptions, with applications in fields such as poetry, music, animation, and especially fashion design (Gero & Chilton, 2019; Huang et al., 2020; Jeon et al., 2021; Mazzone & Elgammal, 2019). These tools democratize access to high-quality creative content generation (Lawton & Ibarrola, 2023; Louie et al., 2020) and streamline the creative process for professionals (Desai et al., 2019; Grabe & Zhu, 2023; Shin et al., 2023; Tholander & Jonsson, 2023; Verheijden & Funk, 2023).

With the recent advancement, generative AI's role in the fashion industry has gained momentum, focusing on improving design processes. Applications include Generative Adversarial Networks (GANs) for apparel design (Cui et al., 2018; Kato et al., 2019) and AI systems like DeepVogue by DeepBlue Technology (Jain, 2019), which use deep generative modeling to support creative efforts (Davis et al., 2023). Recent advancements such as CrossGAI (Deng et al., 2024) and the work by Yan et al. (2022) have developed tools for AI-enhanced sketching and rendering.

Despite advancements in recommendation systems and the generation of fashion images, there remains a knowledge gap regarding how commercial generative AI tools like Bing[5], Midjourney, and DALL-E can be integrated into traditional fashion design processes to augment and accelerate creativity. Understanding these gaps is crucial for designing effective creativity support tools that enhance human creativity in the early stages of design ideation and revision. For instance, the extensive process of image collection for inspiration involves shopping trips, catwalk visits, trade shows, and desk research (Mete, 2006). AI's core function of image generation is well-suited to support the transition from concept development to design development, as shown in Figure 1.

Considering the traditional process, there are three key knowledge gaps in applying current generative AI tools to the early stages of the fashion design process. First, user behavior and requirements: Fashion designers have unique needs that influence how they collect and create inspiration. Without a clear understanding of these needs, it is challenging to design user-friendly (Oppenlaender, 2022) and effective AI systems (Zamfirescu et al., 2023). Research should identify the specific outputs designers find useful, the control they need over AI, and the most helpful types of feedback. Second, understanding designer-AI interaction: Limited research exists on how professional fashion designers interact with generative AI tools. Understanding how designers use these tools to generate and refine concepts (Oppenlaender, 2022), the challenges they face, and how they incorporate AI outputs into their decision-making is essential for tailoring AI tools to fit seamlessly into the design process. Third, impact on creativity and workflow: The impact of generative AI on

the creativity and workflow of fashion designers is not well understood. Research is needed to explore how AI tools influence the creative process, from idea generation to concept refinement (Zamfirescu et al., 2023), and whether they enhance or limit creativity by steering designers toward specific solutions. Additionally, ethical and practical concerns, such as authorship, intellectual property, data privacy, and bias in AI-generated designs, are critical for broader AI tool acceptance in fashion design. Addressing these concerns is essential for integrating AI responsibly and effectively.

This study aims to bridge these gaps by exploring how fashion designers use generative AI for early-stage concept ideation and revision, focusing on tools like Bing, Midjourney, and DALL-E. Through detailed interviews and experiments with fashion experts, the research provides empirical insights into how these tools support and augment the creative processes of professional fashion designers, highlighting the benefits, challenges, and ethical considerations associated with AI in fashion design.

The research addresses three key questions:
1) How does generative AI impact the creativity of fashion designers during the early stage of the design process for ideation and revision?
2) What are the interactions between human designers and AI-generated sketches, and how do these interactions influence design decisions?
3) What ethical issues and biases arise from the use of generative AI in fashion design, and how can they be mitigated?

To explore these questions, we used a mixed-methods approach that included a pilot study, sketch experiment interviews, and a focus group discussion. 19 participants, including design students for the pilot study and professionals, used the AI tools Midjourney and DALL-E to generate fashion sketches for data collection. Data were analyzed using thematic analysis, focusing on the evaluation of AI-generated sketches and the decision-making processes of professional designers.

By integrating interviews and experiments with fashion experts, this study provides a rare exploration of AI-generated design in the fashion industry. The findings provide valuable recommendations on how to better utilize AI as a tool for fashion designers, how to integrate AI-based design tools and workflows, and how to develop AI-based fashion platforms for future applications, especially in the early stages of the design process. This research represents a pioneering effort to understand the intersection of AI and fashion design, providing a comprehensive analysis that benefits both academia and industry.

2. Related Work

By understanding the nuances of fashion design processes, the role of inspiration, the opportunities and challenges of using current AI applications, and ethical considerations,

we can design a user study that effectively explores how generative AI impacts creativity, designer interactions, and ethical issues in the early stages of fashion design. These insights ensured that our research is grounded in existing knowledge while pushing the boundaries to develop more effective and responsible AI tools for the fashion design process.

Fashion design process
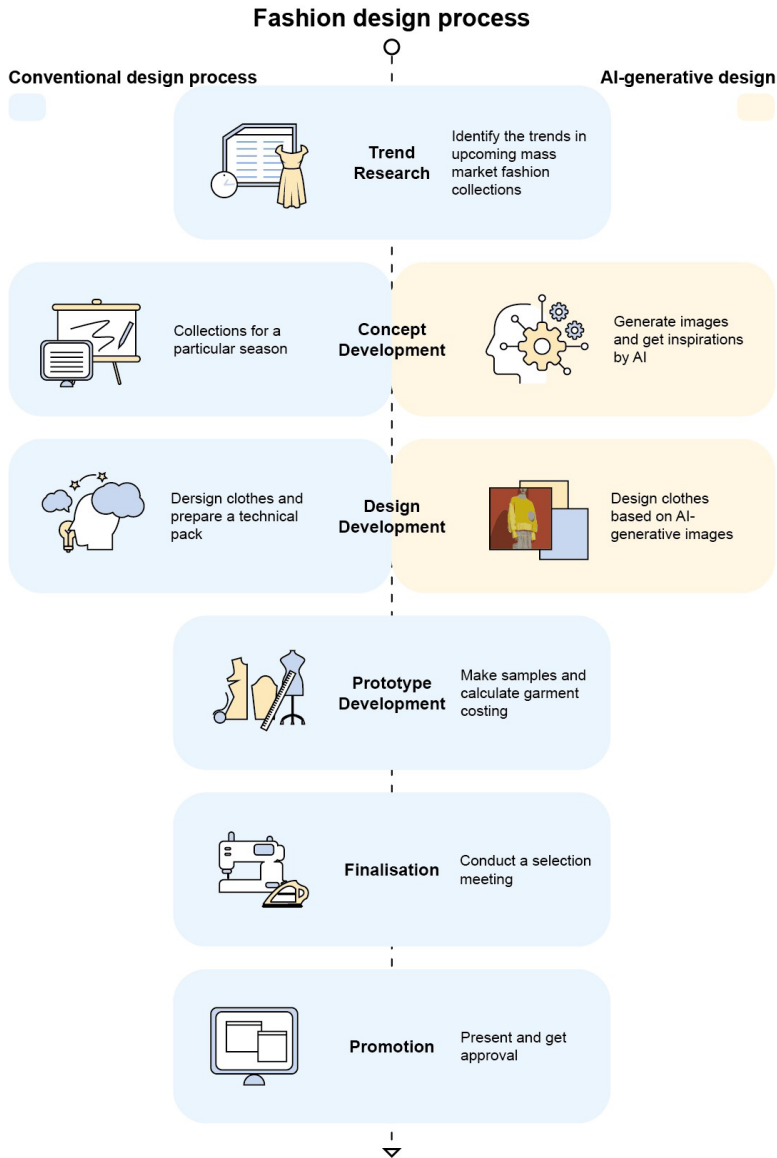
Figure 1 Conventional fashion design process in six steps

2. 1. The Process of Fashion Design

The fashion design process includes various stages, from trend research and initial concept development to final product readiness for the market (Harreis et al., 2023) as shown in Figure 1. Researchers have identified different models, such as the seven-stage model: accept, analyze, define, ideate, select, implement, and evaluate (Jeon et al., 2021; Koberg & Bagnall, 1974; Munasinghe et al., 2021; Watkins, 1988), and a six-step model: trend research,

trend pack development, design development, prototype development, finalization of range, and approval (Fung & Choi, 2018). This process can be condensed into three main phases: idea generation, product development, and production (ElShishtawy et al., 2022; LaBat & Sokolowski, 1999; Kincade et al., 2007). Understanding these steps helped us explore how generative AI tools can be integrated at various stages, particularly during ideation and concept development, to enhance creativity and efficiency.

2. 2. Generative AI in Use for Fashion Idea Generation

Idea generation in fashion design involves collecting and synthesizing inspiration to create new design concepts, a critical process for fostering creativity and innovation (Plucker et al., 2004). Creativity in fashion design is influenced by factors like visual thinking and the continuous search for inspiration from diverse sources such as nature, artwork, history, music, and technology (Mete, 2006; McKim, 1980). Traditional tools like sketches, collages, and mock-ups help transform tacit knowledge into tangible designs designs (Sarmakari & Vanska, 2022; Keller, 2005). While AI can assist in discovering inspirational stimuli, it may also lead to design fixation and inhibit divergent thinking (Wadinambiarachchi et al., 2024; Cai et al., 2023). These insights informed our exploration of how generative AI tools impact design activities, assessing whether they enhance or hinder creative thinking, as Kwon et al. (2023) noted, and how they influence interactions between designers and AI-generated sketches.

Recent research on AI in fashion design has focused on enhancing creativity, personalizing fashion recommendations, optimizing supply chain management, and improving sustainability (Bhattacharya et al., 2022; Dong et al., 2019; Hidayati et al., 2018; Hou et al., 2021). Advanced tools like DMGAN, CLIP, VQGAN+CLIP, and CLIP-guided GAN have proven beneficial in accelerating the design process by providing detailed and diverse design options quickly (Zhu et al., 2019; Radford et al., 2021; Crowson et al., 2022; Smith & Colton, 2021). These tools enable designers to explore various possibilities with fewer resources, representing a new approach to design thinking (Lee & Lin, 2023). Understanding these capabilities and limitations helped us investigate how AI impacts designers' decision-making processes and interactions with AI-generated outputs, providing a benchmark for evaluating the effectiveness of AI tools.

2. 3. Potential Limitations of Generative AI for Fashion Design

Generative AI faces several ethical and technical challenges, such as bias in training data, intellectual property concerns, and the tendency to produce designs reflecting existing dominant styles (Flick & Worrall, 2022). For example, the fashion label Acne Studios' approach of incorporating GAN generations into their Fall 2020 Menswear Collection (Helen, 2020). Also, these tools could inadvertently marginalize minority groups (Flick & Worrall, 2022; Lawton et al., 2023) and lack the novelty needed for truly innovative designs (Grabe & Zhu, 2023). These tools can inadvertently marginalize minority groups and lack the novelty needed for truly innovative designs (Grabe & Zhu, 2023). Also, it is suggested that AI-generated designs often overlook the specific needs of minority groups, including designs for larger individuals, people with disabilities, and those with atypical body shapes (Flick & Worrall, 2022). The subjective and intuitive nature of inspiration in fashion design poses additional challenges for AI integration (Mete, 2006; Stappers & Hennessey, 1999).

Understanding these limitations is essential for addressing the ethical issues and biases arising from the use of generative AI in fashion design. Identifying these challenges helped us develop strategies to ensure responsible and inclusive use of AI, directly addressing the third research question on ethical issues and biases.

3. Methods

3. 1. Pilot Study

Prior to the main study, a pilot study was conducted to test the experimental design and ensure the feasibility of the proposed methods. Seven design students from the (UNIST) participated in this preliminary phase. The pilot study involved a simplified version of the main experiment, where participants engaged with AI tools to create fashion sketches. Feedback from this pilot informed refinements to the experimental design, ensuring that the tasks were clear and that the tools used were appropriate for eliciting meaningful data. We built on our research methods from (Gmeiner et al., 2023; Yildirim et al., 2022; Koch et al., 2019) that they conducted a similar research experiment, but in product design and UX/ UI design topic. We tailored the the experiment into fashion design filed by modifying the design task into a fashion topic.

3. 2. Participant Recruitment

Participants for the main study were recruited using a snowball sampling method, ensuring a diverse range of fashion design professionals. Initial contacts were made through a known fashion designer, who then recommended additional participants. This method was chosen to include designers with varying levels of experience and expertise, ensuring a comprehensive understanding of how different professionals interact with AI tools. In total, 19 participants were recruited, comprising a mix of students, industry professionals, and researchers in fashion design. Demographic information of the participants are presented in Tables 1 and 2 respectively.

3. 3. Experimental Tools

The primary AI tools used in the study were Midjourney and DALL-E, both of which are text-to-image generators capable of producing high-quality fashion sketches from textual descriptions. The choice of tools was influenced by feedback from the pilot study, where participants preferred Midjourney for its user-friendliness and superior output quality compared to other tools like Stable Diffusion. Each participant was provided with access to these tools during the experiment, ensuring consistency in the AI-generated outputs.

3. 4. Main Study Designs

The main study consisted of two components: (1) sketch experiment interviews and an (2) expert focus group discussion.

(1) Sketch Experiment Interviews
Eight fashion designers participated in the sketch experiment interviews, conducted via

Zoom. The sessions were structured into three phases:

- Warm-Up Exercises (10 minutes): Participants engaged in basic tasks to familiarize themselves with the AI tools. This phase aimed to reduce any initial hesitation and ensure participants were comfortable using the technology.
- AI Sketches Drawing Session (5-40 minutes): Participants were tasked with creating one to two fashion sketches for their company's new season development using the AI tools. They were encouraged to base their prompts on recent real projects, making the experiment more realistic and relevant to their professional work. Participants were allowed to choose, revise, and iterate on their prompts independently, simulating a quasi-real design environment.
- In-Depth Interviews (20 minutes): After the sketching session, participants engaged in a detailed interview where they discussed their experiences using the AI tools. These interviews were recorded and transcribed for further analysis. Participants were asked to evaluate the AI-generated sketches using a five-point rating scale across five criteria: Visual Fidelity and Realism, Originality and Creativity, Aesthetics and Composition, Practicality and Wearability, and Designer Input and Customization.

Table 1 Demographic information of participants in the Sketch Experiment

Participant	Age	Current profession	Experience	Education	Prior AI experience
S_1	35	Fashion Director	13 years	Fashion Design (Bachelor's)	Yes
S_2	25	Clothes Designer	3 years	Fashion Design (Master's)	Yes
S_3	25	Lounge–wear Designer	3 years	Fashion Design (Bachelor's)	No
S_4	29	Researcher	4.5 years	Clothing and Textile (Master's)	Yes
S_5	29	Menswear Designer	5 years	Fashion Design (Master's)	Yes
S_6	28	PhD Candidate	4.5 years	Garment Technology (PhD–level)	No
S_7	24	Undergraduate Student	1 years	Fashion Design (Bachelor–level)	Yes
S_8	24	Undergraduate Graduate	2 years	Fashion Design (Bachelor's)	No

(2) Expert Focus Group Discussion

A two-hour online focus group discussion was conducted with 11 fashion practitioners. This session aimed to explore the broader implications of AI-generated designs in the fashion industry. Topics included the strengths and weaknesses of AI in creative processes, the potential impact on traditional design practices, and the opportunities AI presents for future design work. The focus group provided a platform for participants to share their diverse perspectives and experiences, enriching the study's findings.

Table 2 Demographic information of participants in the Focus Group Discussion

Participant	Age	Current profession	Experience	Education	Prior AI experience
F_1	24	Fashion Design Assistant	1 year	Fashion Design	Yes
F_2	32	Customer Relations Specialist	2 years	Marketing	Yes
F_3	28	Fashion Educator	1 year	Fashion Design	Yes
F_4	27	Clothing Designer	4.5 years	Fashion Design	Yes
F_5	24	Clothing Trader	2 years	Fashion Design	Yes
F_6	25	Founder of a fashion brand	2 years	Fashion Design	Yes
F_7	42	Fashion Software Engineer	4 years	Soft Engineering	Yes
F_8	43	Founder of a fashion brand	8 years	Fashion Design	Yes
F_9	24	Function Clothes Designer	2 years	Fashion Design	Yes
F_{10}	26	Fashion Educator	3 years	Fashion Design	Yes
F_{11}	35	Fashion Buyer	5 years	Marketing	No

3. 5. Data Analysis

The data collected from the sketch experiment interviews and the focus group discussion were analyzed using thematic analysis. This method involves coding the data to identify recurring themes and patterns, providing a structured approach to understanding the qualitative insights gathered from participants as shown in Figure 2. The coding process was facilitated by ATLAS.ti, ensuring systematic and rigorous analysis through triangulation.
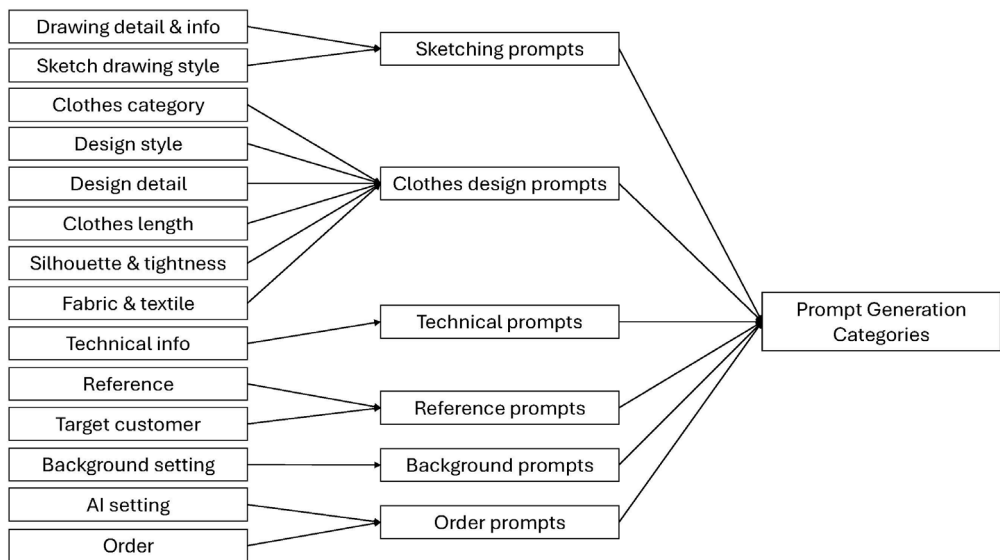
Figure 2 A framework for thematic analysis, coded using ATLAS.ti.

3. 6. Evaluation Criteria

The evaluation of AI-generated sketches was based on a six-question form, focusing on multiple criteria to assess the quality, creativity, and practicality of the designs based on (Lupton, E., & Phillips, J. C., 2015), (Leborg, C., 2006), and (Culpepper, M. K., 2013). We interpret and revise the categories to fit the fashion design field. The criteria were:
 • Visual Fidelity and Realism: Assessing the accuracy and detail of the AI-generated images.

- Originality and Creativity: Evaluating the uniqueness and innovative aspects of the designs.
- Aesthetics and Composition: Considering the overall visual appeal and layout of the sketches.
- Practicality and Wearability: Determining the feasibility of producing and wearing the designs.
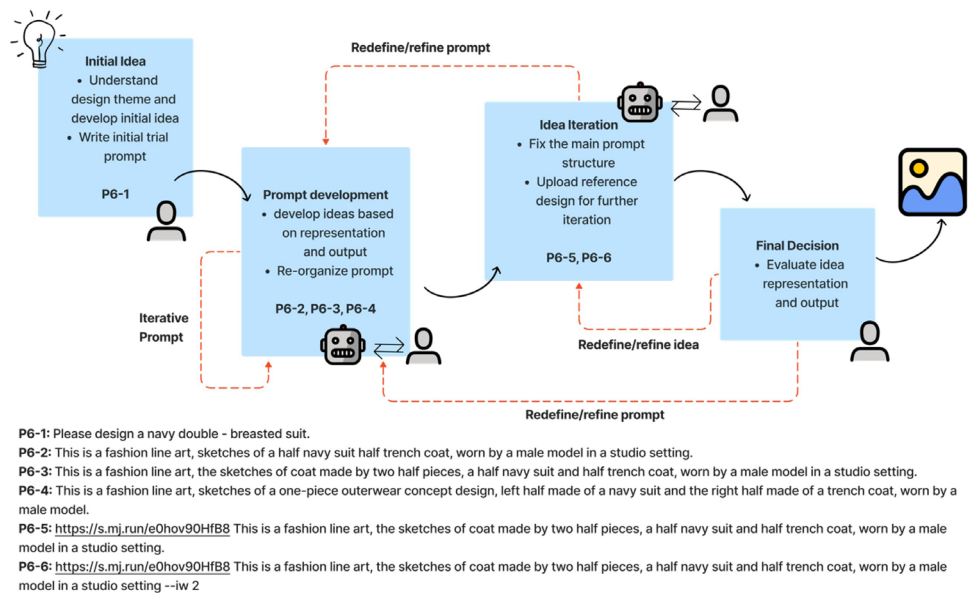- Designer Input and Customization: Measuring the extent to which designers could influence and personalize the AI-generated outputs.

Participants rated these criteria on a five-point scale and provided qualitative feedback, highlighting the strengths and limitations of the AI tools in their creative processes.

As for the visualization materials, we output all the AI-generated images and their prompts from the sketch experiments and uploaded them to Figma. We then organized them by participant and by time, and analyzed each participant's iteration process as shown in Figure 3. This figure represents a workflow map of participant S_6, who uses Midjourney as a tool during his design process. These results could provide a comprehensive understanding of the generative design tools in enhancing the ideation process and creating new meanings and experiences for fashion designers.

P6-1: Please design a navy double - breasted suit.
P6-2: This is a fashion line art, sketches of a half navy suit half trench coat, worn by a male model in a studio setting.
P6-3: This is a fashion line art, the sketches of coat made by two half pieces, a half navy suit and half trench coat, worn by a male model in a studio setting.
P6-4: This is a fashion line art, sketches of a one-piece outerwear concept design, left half made of a navy suit and the right half made of a trench coat, worn by a male model.
P6-5: https://s.mj.run/e0hov90HfB8 This is a fashion line art, the sketches of coat made by two half pieces, a half navy suit and half trench coat, worn by a male model in a studio setting.
P6-6: https://s.mj.run/e0hov90HfB8 This is a fashion line art, the sketches of coat made by two half pieces, a half navy suit and half trench coat, worn by a male model in a studio setting --iw 2

Figure 3 A workflow map of participant S_6 who utilizes Midjourney as a tool during their ideation and revision process.

3. 7. Ethical Considerations

We obtained approval from the Institutional Review Board (IRB) at our institution to ensure that all aspects of our experiment met ethical standards. All participants gave informed consent. Their confidentiality and privacy were strictly maintained throughout the study.

4. Results

The results of this study provide critical insights into how generative AI tools can support and augment the creative processes in the early stages of fashion design, the nature of designers' interactions with AI-generated sketches, and the challenges and ethical considerations associated with using these tools.

4. 1. The designers' evaluation of AI−generated fashion sketches

Participants rated AI-generated fashion sketches based on Visual Fidelity and Realism, Originality and Creativity, Aesthetics and Composition, Practicality and Wearability, and Designer Input and Customization. Designers rated Visual Fidelity and Realism the highest, while Designer Input and Customization received the lowest scores as shown in Table 3. However, designers considered Designer Input and Customization to be the most important category, highlighting a significant gap between AI capabilities and designer needs. Originality and creativity, while considered critical, were also areas where AI performed poorly. These findings suggest that future AI development should focus on improving customization and creativity to better meet the needs of fashion designers.

Table 3 Designers' Prioritized Rating and Ranking of Elements in AI−Inspired Creative Design

Parameter	Rate Mean	Rate Std Dev	Rank Mean	Rank Std Dev
Visual Fidelity and Realism (VFR)	4.25	0.46	1.75	0.71
Aesthetics and Composition (AC)	3.88	0.99	2.50	0.93
Practicality and Wearability (PW)	3.50	1.20	2.50	1.51
Originality and Creativity (OC)	3.25	1.39	3.63	1.30
Designer Input and Customization (DIC)	3.13	0.99	4.63	0.52

4. 2. Human designers and AI−generated tools interaction in creative decision−making

4. 2. 1. Modes of AI usage by fashion designers

Fashion designers utilized AI tools in three primary modes:

Text-to-Sketch for Rapid Concept Realization: Designers use text prompts to generate initial sketches when they have vague concepts in mind as shown in Figure 4. This method provides a tangible representation of their ideas, boosting confidence (Participant S_6).

Hand-Drawn Sketch Enhancement: Designers input hand-drawn sketches into AI tools to add more detailed designs as showan in Figure 5. This is particularly helpful for those with weaker digital sketching skills (Participant S_3).

Software-Assisted Sketch Enhancement: Designers use AI to enhance sketches created with computer software like Adobe Illustrator as shown Figure 6, aiming to visualize fabrics and techniques realistically without creating 3D simulation samples (Participant S_5).

These modes highlight the diverse ways in which AI tools can be integrated into the design process, enhancing different aspects of creative decision-making. Understanding these interactions helps tailor AI tools to better support designers' workflows.

Prompt: This is a fashion line art, sketches of a half navy suit half trench coat, worn by a male model in a studio setting.

Prompt: This is a fashion line art, the sketches of coat made by two half pieces, a half navy suit and half trench coat, worn by a male model in a studio setting.

Figure 4 AI-generated fashion sketches by S6 using Prompt 1: This is a fashion line art, sketches of a half navy suit half trench coat, worn by a male model in a studio setting; Prompt 2: This is a fashion line art, the sketches of coat made by two half pieces, a half navy suit and half trench coat, worn by a male model in a studio setting.

Figure 5 AI-generated fashion sketches by S3. Left: The original fashion design hand drawing sketch input; Right: AI-generated design variation using Prompt: Please design a lady's sun protection shirt with princess line drawstring pleats on the front piece. This shirt can be completely folded and stowed in the left pocket. Please show how the stowage is done and how it is made. Clothing design style, effect.

Figure 6 Left: The original fashion design digital drawing input by S5; Right: AI-generated design variation using Prompt: render this knitwear shirt, causal look, design for men –iw 2.

4. 2. 2. AI tools as a bridge

Some participants emphasized that AI-generated images can provide inspiration and new directions when creativity or artistic skills are lacking. They suggested that AI tools can provide inspiration and new directions when designers face creative blocks. These tools can help visualize and expand conceptual ideas, which can help with brand planning and visual aesthetics (Zhang et al., 2023). They also suggested that AI can combine knowledge from different fields, generating unique design ideas that go beyond individual inspiration. This interdisciplinary approach enriches the creative process, as seen in designs that combine Issey Miyake's style with other elements (Hwang, 2022; Participant F_2). AI's ability to serve as a bridge and blender underscores its role in enhancing creativity and helping designers explore different styles and concepts.

4. 2. 3. Iterative Use of AI to Meet Their Goals

Designers iteratively refine AI-generated images by modifying prompts to align outputs with their vision. Experienced users create more accurate prompts, resulting in outputs that closely match their intentions (Participants S_1, S_2, S_4, S_5, S_7). However, a richer experience did not necessarily translate into faster task completion (Figure 7). AI provides designers with endless ideas and experimentation (Figure 8). However, S_5 also noted that if designers do not have a firm grasp of the intended topic and rely too heavily on AI, they risk being influenced by AI and deviating from their original design intent. Therefore, the iterative nature of using AI tools reflects their potential to enhance design accuracy and creativity. The need for clear design concepts and frameworks remains critical to prevent over-reliance on AI and ensure human-centered design outcomes, as suggested by Liu (2023).
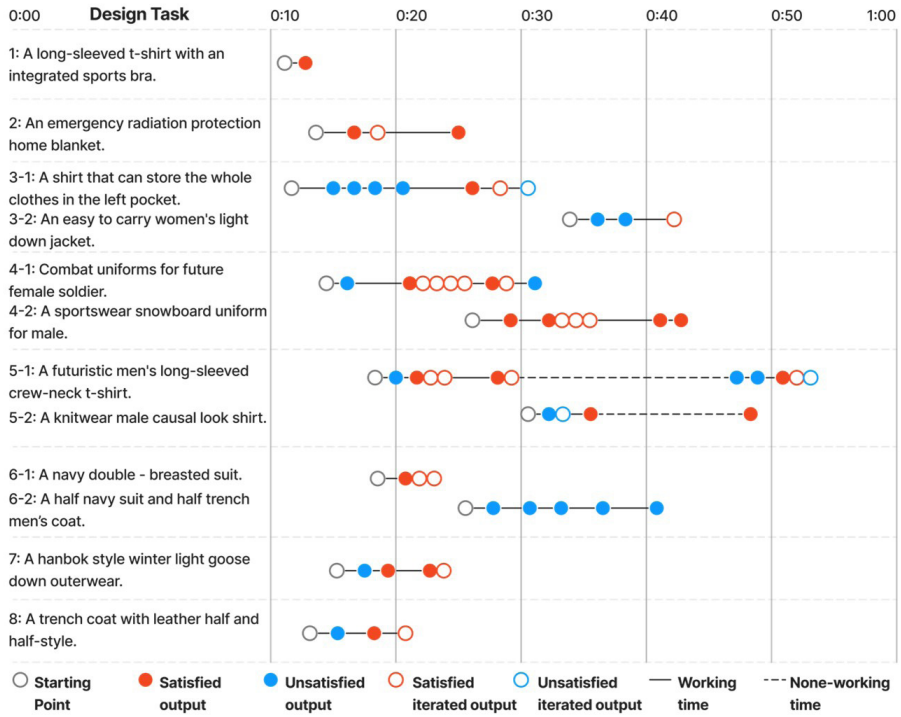
Figure 7 The creative process of participants using AI–generated design tools.

Prompt: Please design a ladies sun protection shirt with princess line drawstring pleats on the front piece. This shirt can be completely folded and stowed in the left pocket. Please show how the stowage is done and how it is made. Clothing design style, effect

Figure 8 AI–generated design variations using Prompt: Please design a lady's sun protection shirt with princess line drawstring pleats on the front piece. This shirt can be completely folded and stowed in the left pocket. Please show how the stowage is done and how it is made. Clothing design style, effect.

4. 3. Challenges, biases, and ethical considerations in fashion design
4. 3. 1. Efficiency generation can inhibit deep thinking.

Participants expressed concerns that AI might inhibit deep thinking by providing straightforward design outcomes lacking reflective dialogue between designers and their media (Maher & Poon, 1996; Schon, 1983). AI-generated images are often perceived as less valuable than designers' original ideas (Participant S_5). There is also a lack of comprehensive copyright laws addressing ownership of AI-generated materials.

4. 3. 2. Understanding issues with AI

AI-generated designs can exhibit randomness, leading to misalignment with designers' intentions (Verheijden & Funk, 2023). Translating ideas into AI prompts often results in less rich or accurate images due to the characteristics of generative AI's image synthesis mechanism. Enhancing designers' knowledge of AI prompts and improving AI's understanding of design terminology is critical for better alignment between AI outputs and creative visions as Figure 9 illustrated. These challenges emphasize the importance of building designers' knowledge of AI prompts and descriptive logic to improve alignment between AI outputs and their creative visions. Enhancing AI's understanding of design terminology is also critical.
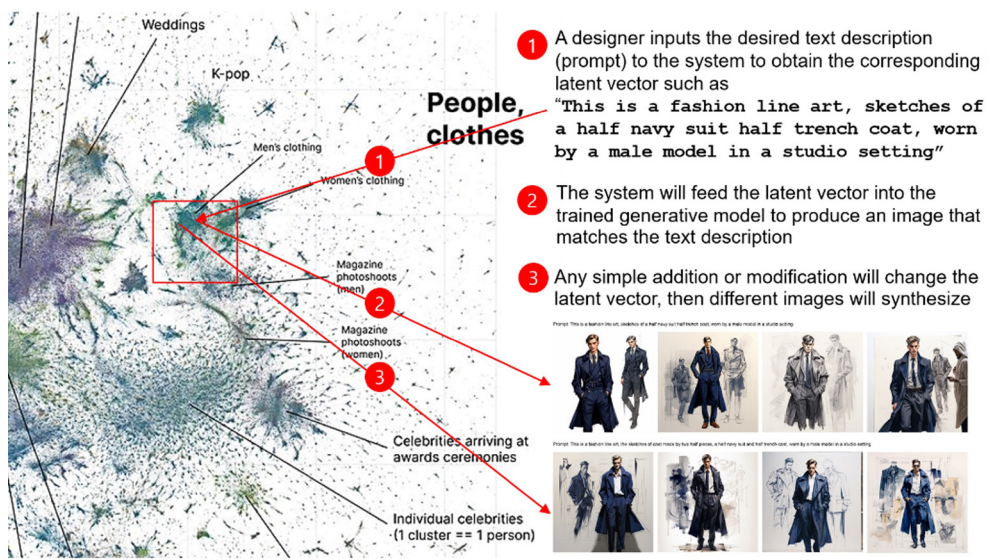

Figure 9 We observed this inequality during the inspiration phase. AI may enrich the designer's idea, diminish it, or, very rarely, match it exactly due to the characteristics of the generative AI using latent space.

4. 3. 3. Limitations of AI Sketches for Novelty and Uniqueness

AI-generated designs can exhibit randomness, leading to misalignment with designers' intentions. The complexity of translating ideas into AI prompts often results in less rich or accurate images (Verheijden & Funk, 2023). Misinterpretation of fashion design terminology further complicates the process (Participant S_5). Participants believed that AI had a limited understanding of some very novel ideas and unique styles, or ideas that did not follow the existing logic. An example is from S_6 "*We found that the AI didn't understand the concept*

fully and generated mostly images of people wearing traditional coats. We attempted to provide a similar image to guide its generation, but the result still didn't match our mental image... it operates based on existing content and doesn't conform to uncommon design principles". AI also have a limited understanding of design principles and human aesthetics. For instance, S_1 mentioned that AI is struggling to grasp the reasonable distribution of muscles and appropriate balance. Moreover, F_8 explained: *"AI is great for creativity and concepts, but clothing needs physical representation, and this intermediate process depends on many factors".* AI has limitations in comprehending unconventional or highly original ideas that defy standard logic. Recognizing these limitations is crucial for developing AI tools that better support the unique and innovative aspects of fashion design. AI should be seen as a complementary tool rather than a replacement for human creativity and detailed craftsmanship.

4. 4. Impact on transforming the fashion design process with generative AI
4. 4. 1. AI tools serve as a starting point.

Participants highlighted the role of generative AI in enhancing efficiency and inspiring creativity during the initial stages of design as Tholander & Jonsson (2023) and Verheijden & Funk (2023) suggested. AI-generated designs are better suited for inspiration rather than final products, aiding in brand planning and image searches but requiring human intervention for execution and detailed design (Participants S_1, S_2, S_4); this confirms (Tholander & Jonsson, 2023; Zhang et al., 2023)'s results. These insights suggest that AI tools should be viewed as starting points for creativity, complemented by human expertise for practical implementation.

4. 4. 2. Fashion designers need customized AI.

Participants identified a gap in the market for AI generative design platforms specifically tailored to fashion design. While platforms like AiDLab[6], Fabrie12[7], and Zhiyi Tech[8]'s Fashion Diffusion Beta exist, they do not fully meet the specific needs of clothing design. Developing specialized AI tools with tailored functionalities, detailed instructions, and advanced search capabilities can better support designers' creative processes as Chiou et al. (2023) and Yildirim et al. (2022) noted.

4. 4. 3. Fashion designers' roles and responsibilities in the future.

The integration of AI in fashion design is creating new roles and responsibilities for designers. However, there is a disparity between the demand for AI skills and the availability of training and real project opportunities. To bridge this gap, fashion companies need to provide more structured training and project opportunities for designers to develop AI skills. Fashion education programs should also incorporate AI training to prepare future designers for effective collaboration with these technologies (Participants S_3, S_4, F_7).

6) AiDLab: https://www.aidlab.hk/en/

7) Fabrie: https://www.fabrie.com/

8) Zhiyi Tech: https://www.zhiyitech.cn/home

5. Discussion

The results of this study provide substantial insights into the role and impact of generative AI tools in the early stages of fashion design, highlighting both the potential benefits and the challenges of existing tools. The findings suggest the importance of customization, interaction dynamics, and ethical considerations for the future creative workflow of fashion designers.

5. 1. Impact of generative AI on the early design activities in Fashion Design

The evaluation of AI-generated fashion sketches reveals that while AI excels in visual fidelity and realism, it falls short in originality, creativity, and customization. This disparity points to a crucial area for improvement in AI tools. For AI to genuinely augment the creative process, it must offer greater flexibility and customization options that align more closely with designers' needs. The true value of AI lies in its capacity to inspire and foster unique, original ideas. Future AI development should prioritize enhancing creative functionalities and providing more sophisticated customization features to support the ideation phase more effectively.

5. 2. Interactions between designers and AI-generated sketches

The study highlights diverse modes of interaction between human designers and AI tools, including text-to-sketch generation, hand-drawn sketch enhancement, and software-assisted sketch refinement. These interactions illustrate how AI can be integrated into different stages of the design process, enhancing creativity and decision-making. Using text prompts to quickly visualize vague concepts boosts designers' confidence, while enhancing hand-drawn sketches with AI helps refine ideas more efficiently. AI tools act as bridges, providing inspiration and new directions when designers face creative blocks. This cross-disciplinary blending of ideas enriches the creative process by enabling designers to explore a broader range of styles and concepts. However, the iterative use of AI, where designers refine outputs through repeated prompt modifications, highlights a potential dependency risk. While AI can offer endless ideas and experimentation opportunities, there is a risk of designers deviating from their original intent if they overly rely on AI-generated suggestions. Designers need to maintain a clear framework and design concept to ensure AI complements rather than overshadows their creative vision.

5. 3. Ethical issues in data and biases in visual materials generated

The study identifies several ethical concerns and biases associated with AI-generated designs. Participants expressed worries about AI inhibiting deep, reflective thinking, as the straightforward design outcomes provided by AI can lack the nuanced dialogue between designer and media essential for creativity. The perception that AI-generated images are less valuable than original ideas also highlights a significant challenge in integrating AI into creative processes. Additionally, the lack of comprehensive copyright laws for AI-generated materials poses a legal and ethical dilemma, emphasizing the need for clearer regulations to protect designers' intellectual property.

Understanding issues with AI, such as the randomness and misalignment of AI-generated designs with designers' intentions, complicates the integration of AI in fashion design. Translating ideas into AI prompts often results in less rich or accurate images, highlighting the importance of building designers' knowledge of AI prompts and improving AI's understanding of design terminology. Enhancing AI's ability to accurately interpret and generate designs based on specific fashion terminology is critical for better alignment with designers' creative visions.

5. 4. Practical and ethical implications

To fully leverage the benefits of generative AI in fashion design, developers need to focus on enhancing the customization and creative capabilities of AI tools. Providing designers with more control over AI-generated outputs and integrating advanced customization options will help align these tools with the specific needs of the fashion industry. Ethically, it is crucial to address the biases and limitations of AI-generated designs. Ensuring that AI tools do not perpetuate existing biases or marginalize minority groups is essential for creating inclusive and diverse fashion designs. Developing clearer guidelines and regulations regarding the ownership and copyright of AI-generated designs will help protect designers' intellectual property and foster a more ethical integration of AI in fashion design.

6. Conclusion

This study provides substantial insights into the role of generative AI tools in the early stages of fashion design, highlighting their potential to enhance creativity and streamline the design process. AI tools like Midjourney, DALL-E, and Bing can significantly augment the creative processes of fashion designers by providing rapid, diverse visual stimuli. However, the findings reveal that while AI excels in generating visually realistic and detailed images, it falls short in originality, creativity, and customization. To genuinely augment the creative process, future AI development must prioritize enhancing these creative functionalities and offering more sophisticated customization options.

Interactions between designers and AI tools are diverse, ranging from text-to-sketch generation to hand-drawn and software-assisted sketch enhancements. These interactions help integrate AI into different stages of the design process, enhancing creativity and decision-making. Nevertheless, the iterative use of AI highlights a potential dependency risk, underscoring the need for designers to maintain a clear framework and design concept to ensure AI complements rather than overshadows their creative vision.

Ethical concerns and biases in AI-generated designs present significant challenges. Issues such as inhibiting deep reflective thinking, perceived lower value of AI-generated images, and the lack of comprehensive copyright laws for AI-generated materials highlight the need for ethical guidelines and clearer regulations. Addressing these concerns is crucial for the responsible and inclusive use of AI in fashion design.

Despite its contributions, this study has several limitations. The relatively small sample size and the specific demographic of participants may limit the generalizability of the findings. The study also primarily utilized Midjourney and DALL-E, which, while effective, represent only a subset of available AI tools, and the design tasks in this study were limited to initial ideation and sketching. Lastly, this study did not address into the long-term impact of generative AI on the fashion design process and desginers' reliance.

Future research should explore a broader range of AI tools and their long-term impacts on the fashion design process. Investigating how AI can be tailored to support specific design needs and preferences will be crucial. Furthermore, addressing ethical concerns and biases through comprehensive studies will help develop clearer guidelines and regulations for AI integration in fashion design. Expanding the scope to include the later stages of the design process will provide a more holistic understanding of AI's role in the fashion industry. Finally, future work should consider larger, more diverse sample sizes to validate and extend the findings of this study.

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