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RESEARCH ARTICLE

Generative Artificial Intelligence in Collaborative Ideation: Educational Insight From Fashion Students

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ABSTRACT Image-generating AI provides diverse sources for ideation in fashion design education. This study explores how collaborative fashion ideation with AI influences image thinking and creativity in a changing media environment. The research method employed design workshops and in-depth interviews with 10 students. The findings reveal that collaborative fashion ideation with AI influences image thinking through visual expansion, exploration of its applicability in fashion, and identifying and lack of sociocultural understanding and identity in idea combination. Collaborative fashion ideation with AI emphasizes creative properties, such as originality, fluency, and flexibility. The results of design workshops, evaluated by experts, indicate higher originality and novelty compared to the control group. The results imply that various factors, such as individual aesthetic presence and the identity of fashion brands, contribute to fashion ideation. Therefore, in collaborative ideation with AI, rather than relying solely on AI tools, it is essential to perceive and approach them as auxiliary tools. This study contributes to elucidating students' image thinking and creative attributes in fashion ideation, highlighting the impact of collaborative ideation with AI.

INDEX TERMS Generative artificial intelligence, humans-AI interaction, image thinking, collaborative creativity, fashion education.

I. INTRODUCTION

Enhancing creativity among students is crucial in the digital technology era as creativity plays a vital role in fashion design education. It is a dynamic entity shaped and transformed through interactions with societal, cultural, and historical systems within cultural practices [1], [2].

Co-creativity, referred to as computational creativity, entails collaborative and synthetic contributions from multiple fields to the creative processes [3]. It involves human-computer interactions influencing each other to create shared artifacts. However, how is human creativity influenced by artificial intelligence (AI) as a cooperative agency?

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The rapid advancement of AI technology has positively impacted the fashion industry; however, concerns have been raised regarding its potential intrusion into human domains, including creativity, in educational dimensions [4]. In cultural and artistic fields, where creativity and emotion are paramount, AI has gained recognition for its qualitative contributions [5]. The impact of generative AI (GAI) technology is expected to be even greater due to the low entry barrier provided by multiple open sources, and the availability of various applications to the public. Recently, fashion designs have embraced the positive utility of such technologies. Both experts and the general public have participated in AI fashion shows and collaborated in AI-generated collections [6], [7].

In the fashion design process, image thinking, using visual data, plays a role in ideation, specifically, in fashion ideation.

Image thinking is the process of reconstructing new images formed during visual information processing through a systematic reasoning process [8]. It selectively accepts visual information and integrates human a priori experiences, recognition of current problems, and predictions. Comprehensive thinking [9] has several advantages over verbal thinking in the cognitive system of the creative process [10] and is being applied to fashion design development. Therefore, this study highlights the interaction between image-generative AI and human creativity in the ideation phase of fashion design development.

Although numerous studies in the fashion field have explored AI applications, they have often overlooked the reflective creative attributes of generative AI. The predominant focus of applying generative AI technology in fashion design has been on the design processes [11], [12], [13] and model development for personalized style recommendations [14], [15]. Educational approaches to AI reflect these aspects conservatively and critically [16]. Additionally, studies exploring AI's impact on students' aesthetic values [17] and relational artifacts in creative learning [18] question AI's creativity and effectiveness, leaving certain aspects unexplored. These complex results do not reflect the fashion field's unique nature, which requires newness and originality.

Therefore, this study targeted fashion students to investigate the impact of collaborative fashion ideation using AI on their image thinking and creativity. The results provide insights into adapting to the imminent future of the fashion industry, coexisting with generative AI, and fostering creative talent. Specifically, the following research questions are explored: What is collaborative AI technology in the fashion design field? What is the relationship between image thinking and creativity in fashion ideation? and How do image thinking and creative attributes manifest in collaborative fashion ideation using image-generating AI? A qualitative research method was employed in workshops with fashion students to address these questions. The study discusses the results from the perspective of fashion design education.

II. LITERATURE REVIEW

A. AI TECHNOLOGY IN THE CONTEXT OF FASHION DESIGN

Collaborative AI technologies applicable to fashion design development can be categorized into three parts based on the core AI technology. First, a Convolutional Neural Network (CNN), capable of extracting features from existing data and making predictions, enables the analysis of fashion design factors from images, such as silhouettes, colors, and textiles [19], [20]. This allows the identification of characteristics indicative of changes in fashion trends and facilitates predictions [21]. In addition, fundamental information for fashion design and product development can be obtained by detecting consumers' body shapes and proportions [22], [23],

providing essential insights for fashion design and product development.

Second, the results obtained from understanding consumer characteristics can be connected to style recommendations [22]. Memory-augmented neural networks (MANN) reduce errors in recurrent neural network technology where the output generated by the input influences subsequent learning. MANNs are employed to consider user preferences for recommending fashion products and styles [24].

Third, in addition to analyzing existing data, AI technologies can generate fashion images. Image-generating AI technologies, such as Creative Adversarial Networks (CAN) and Generative Adversarial Networks (GAN), leverage self-reflective modification and learning systems to create diverse data [25], [26]. Image-generating AI platforms with low entry barriers, such as DALLE and Midjourney, are prominent examples. These platforms use vast amounts of publicly available data from the Internet and repositories [27]. These models can be used to present new fashion items [28] and styles [29], [30] to designers by creating new fashion images.

The collaborative relationship between AI and fashion designers enhances sophisticated design and expression and enables designers with limited reading time to analyze vast amounts of data containing specific consumer groups' preferences. It provides guidelines for developing new fashion designs. However, this perspective concentrates on productivity and efficiency, and lacks deep engagement with designers and brands, during the fashion ideation process. This can be problematic for designers or fashion brands where personal taste or identity is important. This sparks a debate on whether collaborative relationships with AI create new opportunities for designers or disrupt the job market in creative fields [31]. Therefore, it is necessary to explore whether the interaction between humans and AI hinders or promotes creativity.

B. CREATIVITY AND CO-CREATION WITH AI

Creativity is the human ability to generate novel and valuable outcomes [32]. It involves the process of human imagination through interactions between problem perception, social context, environment, and individuals [33], [34]. Creative individuals generate new ideas through divergent thinking [32], and creativity emerges through the interaction between human thought and sociocultural contexts [34]. Creativity is a dynamic process based on psychological needs and socio-environmental influences, involving dynamic processes of creative or divergent thinking [35].

Since creativity possesses novelty and value [36], it refers to collaborative acts in which multiple parties contribute, collectively and in a mixed manner, to the creative process [3]. Researchers bridging computer science and creativity have developed frameworks based on psychological theories of creativity, developing autonomous systems capable of generating creative solutions and artistic outcomes [37], [38]. In collaborative design processes, non-human entities, such

as AI, can be involved [39], and these collaborative systems influence each other [40], with varying impacts based on how contributors participate in the process [41].

Studies have explored the impact of AI on creative human activities, particularly in co-creation tasks. Liao et al. [42] demonstrated that AI can play a participatory role by reproducing ideas for inspiration, serving as an empathetic trigger to assist designers in technical thinking and aiding in fulfilling typical design roles. Conversely, Kim and Maher [41] contradicted this, showing that AI-based design ideation systems can generate numerous novel ideas initially, however, tend to converge with control groups as the process progresses. Regarding outcomes, Pandya et al. [43] and Zhang et al. [44] indicated that AI's performance in collaborative tasks could lead to positive and negative results, depending on its functionalities.

Thus, the influence of co-creation with AI can vary at different stages of the collaborative process, and outcome evaluations may differ across fields. With time constraints, sensitivity to trends, and the intricate demand for utility and aesthetic expression, fashion design necessitates a more nuanced approach to evaluating creative results. Given that fashion creativity relies on contemporary individuals' acceptance of fashion products in a sociocultural context [45], different perspectives on creative outcomes are required.

C. FASHION CREATIVITY AND IMAGE THINKING IN FASHION IDEATION

1) FASHION CREATIVITY

The concept of fashion creativity is somewhat ambiguous as there are differences in perception across fields [46]. Artistic creativity, which begins vaguely, is distinguished from scientific creativity, which begins with problem definition [47]. Given the fashion field's unique position in these realms, it is essential to adopt an approach that distinguishes between them. The demand for fashion creativity exceeds the availability of new consumer goods, instilling desires for change and creating additional requirements to generate value [48]. The creative attributes required and their relationships with the structure and influence of the fashion industry are specific to this industry [45]. Thus, this study focused on understanding fashion creativity during the ideation phase in the early stages of fashion design development.

2) FASHION IDEATION

Research defines the fashion design process as problem identification, conceptualization, design refinement, prototype development, evaluation, and implementation [49], [50], [51], [52]. Among these, the first three stages are closely related to image-thinking processes because they require recognition and creation activities, such as perception, conceptualization in mind, and image search or drawing. This study defines fashion ideation as the process of inspiration and conception that occurs during the ideation phase of fashion design development.

3) IMAGE THINKING

Image thinking refers to the cognitive ability to think perceptually, using images, often in conjunction with visual thinking [53]. It involves the formation of new images through systematic reasoning processes during visual information processing [8]. Compared to linguistic thinking in the creative cognitive system, image thinking offers advantages, such as flexibility in transformation into various representations and free association [10], [54]. In design ideation, image thinking is effectively utilized [55], playing a crucial role in the visually oriented field of fashion design. In society, dealing with complex and ambiguous information across various fields [56], image thinking is particularly important in the visual-centric field of fashion design.

In fashion ideation, image thinking is executed and trained using mood boards. These mood boards are composed of images arranged according to specific concepts that convey stories, generate emotions, and create arguments. In this recontextualization process, creators connect different images and create meaning for new purposes. Considering creativity as the ability to connect seemingly distant elements [57], such mapping is crucial, and image thinking, using mood boards, is effective in fashion design education [58].

Collaborative ideation with AI challenges human creativity by altering or diminishing image thinking and creative development opportunities required for collecting, selecting, and combining images manually. For instance, images in fashion ideation are the most frequently used source. The process of AI-based image generation involves human participation as individuals respond to the system's autonomous responses to fit their expectations [31]. In addition, these systems use internet-scale data that may involve copyright issues [59], social biases, and stereotypes [60]. These issues have sparked discussions about whether collaborative fashion ideation with AI creates new opportunities for designers or disrupts the job market in creative fields [31]. Considering these challenges, it is necessary to investigate the impact of collaborative fashion ideation using AI on students' image thinking and creativity.

III. METHOD

A. RESEARCH DESIGN

This study employs a combination of modified research creation and content analysis methods. The research-creation method, focused on human imagination toward new digital technologies based on vital materialism [61], was applied to the training of prospective educators in image-generative AI and to gather opinions on new technologies through focus group interviews [16]. The research-creation method is an experiential qualitative research method in which participants engage in the creation of creative artifacts using new digital technologies, and their thoughts and emotions during this experience serve as data. This study applies this

method to explore the potential impact of the experience with new digital technologies on creativity. Design workshops were conducted, followed by interviews and analysis of the artifacts.

B. DESIGN WORKSHOPS

The design workshops comprised three sessions of 40 minutes each, totaling 120 minutes. The theme was unified as “fun,” and each session included ideation and creation of a mood map, the development of a fashion style map, and a sketch session based on the types of creativity. According to Boden’s [47] concept of creativity, human creativity can be classified as combinational, exploratory, and transformational. Mood and style maps for fashion design involve divergent thinking, combining ideas in new ways, and exploring various design aspects. This process allows for extensive transformation through sketching, aligning with Boden’s classification of creativity.

The design workshop adhered to the initial design idea stage of the comprehensive fashion design development process outlined previously. At the outset, participants received a topic assignment and commenced idea exploration through internet searches. Subsequently, they transformed their ideas into a mood map, developed a detailed fashion style map, and concluded with pencil sketches of their designs.

The workshop participants were divided into two groups: Group A did not use an image-generative AI platform, while Group B used the platform Midjourney. They were allowed to use basic graphic tools, such as Photoshop and Illustrator, to produce maps and pencil/paper for sketching. Group B, utilizing the AI platform, received an additional 20-minute explanation about the usage instructions since it was new for all the participants. Midjourney is an image-generative AI platform that generates images from natural language descriptions. It was applied to the design workshop because it specializes in abstract artistic expressions and is relatively easy to learn.

C. AI TOOL AND UTILIZATION

In this study, Midjourney served as the GAI tool, grounded in the Stable Diffusion AI painting paradigm [87]. Midjourney functions as a text-to-image creation tool, starting with a randomized noise image upon receiving a text prompt, based on a diffusion model. Through numerous iterative steps, it systematically refines the noise into a coherent image [88]. Version 5, employed in this research and launched in June 2023, significantly improves the quality of output compared with previous versions. These improvements include the generation of more lifelike images, enhanced color accuracy, and a more sophisticated interpretation of prompts [89]. Using Midjourney involves inputting prompts to generate images, merging multiple images, or uploading desired content via Discord, a multifaceted communication platform that supports voice, chat, and video calls. Users also have

the opportunity to review prompts and results from other participants as a reference.

In this research, participants aimed to create a fashion design for the 2024 Spring/Summer season following a given theme. During the conceptualization phase, they collected images from diverse internet sources and utilized Midjourney to assist in crafting mood and style maps. Participants used Midjourney for compositing images or incorporating text as needed, iterating on the design until reaching the desired outcome. New images were created by referencing Midjourney’s outputs, which were then used to generate another novel image. Considering that only English was allowed for input prompts, participants not native in English might have faced challenges. To mitigate this, instructions on commands and basic writing techniques were provided at the beginning of the workshop, with the option for participants to use translators if necessary.

D. PARTICIPANTS AND INTERVIEWS

The purpose of qualitative research is the description, interpretation, insight, and discovery of specific phenomena. It is important to focus on cases that provide in-depth and rich information related to the research content [62]. There have been several discussions about the criteria for selecting the number of participants in qualitative research [63], however, considering that it is common to select five to ten cases, a total of ten people (five for each group) were selected as research participants, using purposive snowball sampling methods. The participants were college students who aspired to become fashion designers after their three to four years of university majoring in fashion. The design workshop and interviews were conducted from October 1 to November 30, 2023, under an institutional bioethics review (IRB approval no. 7001066-202308-HR-050). The gender distribution of the participants was seven women and three men. In terms of age, there were six individuals aged between 22-23 years, two individuals aged 24 years, and two individuals aged 26 years. For Group A, which did not use an image-generative AI platform, one interview was conducted post-mortem. For Group B, which used AI tools, pre- and post-interviews were conducted, each interview lasting for 30 minutes.

Semi-structured interviews are flexible in presenting different types of questions depending on participants’ responses, allowing for an open atmosphere, freedom from time constraints, and an in-depth discussion of results, even with a small sample size [64]. Accordingly, as shown in Table 1, interviews were conducted using a semi-structured questionnaire that included questions about the fashion design process, fashion ideation, and creativity. The recorded interviews were converted into text using CLOVA NOTE, and the researcher transferred them to a word processing program and cleaned and organized them.

E. DATA ANALYSIS AND EVALUATION CRITERIA

Interview data were divided into two categories: image thinking and creative attributes. First, in line with Guilford [32],

TABLE 1. Unstructured questionnaires.

		Questionnaires
Pre		<ul style="list-style-type: none"> • What process is used to develop fashion design? • What is the most difficult thing in fashion ideation? • What is the most important consideration in fashion ideation? • What do you spend much time on during the fashion design process? • How do you usually perform fashion design assignments?
Post		<ul style="list-style-type: none"> • How was this design workshop? • How was the AI platform used in the design workshop? • How was it different from your regular fashion ideation process? • How did you feel about fashion ideation with AI? • Was the AI platform helpful as a way to discover new ideas? • Has there ever been a change in thinking/perspective during the design workshop? • According to you, what are the pros and cons of this collaborative method?

who demonstrated that creative thinking is largely divided into divergent and convergent thinking, image thinking was further divided into divergent and convergent dimensions. The differences between the groups were examined. Second, various discussions on creativity [32], [65], [66] were organized based on common content. An analysis was conducted to understand how creative attributes appeared in each session. These attributes include originality (to generate unique and novel new ideas), fluency (to generate a large number of ideas on a topic), sensitivity (to express feelings about problems or life experiences), sophistication (to develop raw ideas into an accurate state), flexibility (that changes thinking quickly by changing the fixed perspective), abstraction (to find specific relationships or analyses various elements inherent in a problem), and reconstruction (to exclude existing interpretations of a problem and redefine and construct it in a new way).

Image maps and sketches of the participants were collected as a result of the research. This result is based on the design creativity evaluation criteria of the Consensual Assessment Technique (CAT) by Amabile [67] for mood maps, and The Creative Products Analysis Matrix (CPAM) by Besemer and Treffinger [68] for fashion style maps and drawings, considering each characteristic. The evaluation was conducted using a 7-point Likert scale by three experts with doctoral degrees and more than three years of teaching experience in the field of fashion design.

Amabile's [67] CAT enabled test participants to generate creative products while allowing experts to evaluate the degree of creativity. The test is applied to collage or story-making activities. Evaluation elements of collage-making activities include originality, diversity in the use of materials, appropriateness of expressions, harmonious screen composition, and detailed descriptions. Besemer and Treffinger [68] presented the CPAM as a framework for evaluating the creative aspects of various products. The components of the creative output concept were divided into four categories and 13 subcategories: novelty, solution, sophistication, and

comprehensiveness. Based upon this framework, the results of Session 1 were based on originality, diversity of source use, appropriateness of expression, harmony, and detail of expression. Meanwhile, the results of Sessions 2 and 3 were based on newness, solvency, sophistication, originality, usefulness, attractiveness, and completeness.

IV. ANALYSIS AND RESULTS

A. IMAGE THINKING IN FASHION IDEATION

1) INDEPENDENT IMAGE THINKING

a: SENSORY PERCEPTION AND DIVERGENCE IN FASHION INFORMATION

While there were certain individual differences, the participants in Group A used a variety of visual images to select topics and perceived a diverse range of information. Individual tastes were reflected in the process and each step was either omitted or repeated.

"I generally get inspiration from images of other people's lifestyles or mood films that I find on Pinterest or YouTube." (Participant A5)

"I tend to explore overall fashion trends. For example, if bomber jackets are trending, I search for that item on Google or Pinterest. Among the collected information, I focus on futuristic elements as I prefer futuristic styles, and I try to reflect that mood in my designs." (Participant B1Pre)

In fashion ideation, exploring photos or videos helps confirm color and shape information and develop various ideas. In fashion design development, visual information about fashion trends or items serves as a foundation for idea development. Hence, image thinking perceives fashion information sensitively.

b: VISUAL EXPLORATION AND CONVERGENCE OF DIVERSE IDEAS

Participants emphasized the importance of image searches through the Internet and social media platforms in fashion ideation. Social media algorithms and hypertext functions

facilitated image thinking, and participants showed a dependency on these tools.

“Following photos on Instagram sometimes connects to other sites, expanding the provided keywords, which helps develop thoughts. Looking at the search results images changes and refines my thinking....” (Participant A3)

Recommendation algorithms and hypertext features on social media platforms visually reveal the correlation between photos and keywords, facilitating divergent image thinking and aiding participants who occasionally rely on these features.

“Once images are collected and I think about them, I use computer programs like Photoshop or Illustrator to reconstruct the images. In some cases, I directly draw on them to add ideas. The computer work is repeated.” (Participant B3Pre)

The collected materials were converted into new visual materials, considering their aesthetic taste and design purpose. In this process, images are grouped or collated by selecting and recombining various visual materials based on their organic connectivity. This approach to image thinking is grounded in the divergence and combination of organic ideas derived from visual materials.

2) IMAGE THINKING IN FASHION CO-IDEATION

Visual expansion and exploration of applicability in fashion: In collaborative ideation with AI, participants experienced both the expansion and limitations of ideas. AI, which provides a broader range of images, was considered helpful in expanding personal thoughts.

“When searching for images, I can see a lot more, so it helps expand my thoughts. If Pinterest shows only what I’m looking for, AI felt like it went a bit further in showing suggestions.” (Participant B2Post)

“It broadens my thoughts in areas I hadn’t thought of, and when creating a mood map, it allows me to create something unique that can’t be found on the Internet.” (Participant B5Post)

However, responses to the experience and AI platforms may not deliver accurate fashion-related images, and their applicability to fashion ideation may have limitations.

“It tends to show images related to the given keywords or loses direction when abstract keywords are used. It was challenging to apply it to fashion design.” (Participant B4Post)

Nonetheless, AI images that surpass physical representations can offer new perspectives and serve as sources of diverse inspiration. Outcomes extending beyond the understanding of the fashion field paradoxically offer opportunities to explore how to relate them to the fashion domain. Experts believe that creativity is the ability to connect elements that may seem distant [58]. In cognitive psychology, representation is similar to neural organization in the brain, and the combination of various forms of representation generates new concepts [11]. From a professional and critical perspective, image thinking, resulting from the combination

of image-generative AI and human efforts to integrate them, can contribute to the development of creativity.

a: LACK OF SOCIOCULTURAL UNDERSTANDING AND IDENTITY IN IDEA COMBINATION

While AI collaboration does not provide fashion-related images as accurately as independent Internet searches, it enables unique and natural combinations of ideas.

“I liked being able to unfold my thoughts using photos I liked. Merging two photos or changing one immediately produced results, and based on that, I could express images closer to my thoughts by entering more commands. However, I was a bit surprised; I entered ‘princess and amusement park,’ and the result was a Disney-style princess. It was clearly Disneyland. I had never used the word Disney.” (Participant B5Post)

Even when user intentions are explicitly demanding, AI images that utilize images and texts from public repositories may not sufficiently reflect the context of the requirements. Designers working within the framework of a specific era and sociocultural background may require a specific brand identity or personal aesthetic characteristic. However, the results of collaborative ideation with AI lacked sociocultural understanding and personal identity, demonstrating the inherent property of image thinking related to the convergence of ideas by combining them through its algorithm.

B. CREATIVE VS CO-CREATIVE PROPERTIES IN FASHION IDEATION

1) CREATIVITY IN FASHION IDEATION

Session 1 (S1): Collecting ideas and mood mapping: During this stage, participants developed ideas centered on keywords using mind maps or collected visual materials and inspirations by searching for keywords on the Internet and social media platforms. A mind map expands thinking around core concepts, and finding connections between concepts using this method stimulates creative thinking [69], [70]. Mind maps are a type of image thinking tool for organizing thoughts, using images, keywords, symbols, etc., disseminating and reorganizing information, and visually implementing thoughts [71].

“I drew a mind map, thinking about what I usually enjoy. I brainstormed and used the derived words to find images. Based on the found images, I developed ideas while selecting the desired feelings.” (Participant A1)

“I followed related keywords, entered algorithms, found images, developed ideas inspired by those images, and selected images with colors or moods that I liked.” (Participant A4)

The initial exploration phase of fashion ideation requires the collection and divergence of diverse ideas. Material selection is influenced by aesthetic preferences and is the ultimate goal of fashion design. In other words, it is related to fluency in generating various ideas, projecting

one's experiences, sensitivity to discovering new ideas, and the abstraction associated with finding and analyzing the relationships between various design elements.

Session 2 (S2): Style map creation: Creating a style map in the process of fashion ideation, that is, style mapping, is a creative act that represents a designer's mental image by visualizing materials containing motifs or metaphors reminiscent of various formative features or emotional images in a collage. In this process, participants selected and recombined images according to the design direction and mood envisioned, and used tools with which they were familiar.

"For photos with backgrounds that I liked, I used only the background when creating the style map. For clothing, I selected only the necessary parts and synthesized them using Photoshop... It seems like there are predetermined elements I want, such as the desired pose and tone. The saturation is a bit low, and it involves sculptural compositions in architecture. There should also be some whitespace. It seems like creating a map to reflect such a style, and if I didn't have the necessary images during the creation, I would search for them again..." (Participant A5)

The participants completed the process by selecting, disassembling, reorganizing, adding, and deleting the collected photos, and some repeated the process of searching for additional materials on the Internet. Style mapping is convergent thinking that comprehensively judges various types of information. In this process, the creative properties of abstraction and reconstruction were confirmed, focusing on how to organize each visual material harmoniously and reflect one's aesthetic identity.

Session 3 (S3): Sketch visualization: Sketching involves a cognitive perception and visualization process that enables designers to perceive, think diversely, and imagine from new perspectives [72]. It serves as an essential tool for designers to develop their thoughts [73], aiding the immediate visualization of ideas, and plays an important role in idea generation, development, and sharing [74]. Participants transformed visually collected and creatively generated materials, based on their identities, into evolving clothing forms. This stage requires expertise in garment structure, production-related knowledge, and drawing skills.

"Drawing took the most time. It usually takes a significant amount of time for me, and approximately 65% of the entire process is allocated to drawing. In this process, I engage in thinking, and it seems like the thinking phase consumes the most time. While image searching and mapping don't feel burdensome, there is a psychological burden when it comes to drawing." (Participant A5)

This suggests a connection between proficiency and creativity. Drawing techniques and knowledge of clothing structures and design elements can vary among individuals. For instance, Participant A5 finds recombination using existing data easy, however, expresses a sense of burden when it comes to the detailed development of designs

and sketches. In contrast, other participants mentioned that simpler tools, such as pencils and paper, were more helpful in generating and expressing a greater number of ideas.

"Paper feels more tactile to me than digital, and I think the design turned out well. The sound of it also felt like white noise, helping me concentrate better." (A4)

"I usually use the Procreate app on my iPad, but today, paper and pencil were so comfortable. It feels like the lines follow what I have in mind, and things like pressure sensitivity are even better." (Participant A1)

In summary, differences in professional knowledge, technical skills, and fashion-design tools are likely to affect creativity. Participants who revealed that they usually use digital tools, such as iPads, reported that the change in tools helped them develop more fluency and elaborate ideas. This suggests that it may affect the creative properties of fluency and sophistication.

2) CO-CREATIVITY IN FASHION IDEATION

S1: In collaborative ideation, participants successfully collected a vast number of images, encompassing a collection of diverse categories of unexpected images. Throughout this process, they interacted with the computer by entering prompts 3-10 times to generate the desired images. Shifts in thinking occurred during this interaction.

"AI platform allowed me to create what I wanted continuously, just as I envisioned, and I was able to do it without any regrets. However, initially, I wasn't sure what words to input. I had the idea of a flower-filled innocence in mind, but at times, I ended up with strange images." (Participant B2 Post)

"I originally wanted to give it more of a 2D-pixel feel, but while generating images with AI, I found it unique that it could also create 3D pixel images, which I liked." (Participant B4 Post)

However, these advantages do not necessarily imply the acquisition of original visual materials. Instead, several of the generated visual materials are perceived as commonplace. Participants mentioned that compared to their previous Internet search methods, collaboration with AI produced more conventional and fragmented images, which they found less innovative and helpful for groundbreaking ideation.

"Instead, there are quite a few common things. Honestly, Pinterest has a well-functioning algorithm, and there is actual data on clothing made by people, so in terms of details, Pinterest is better because its algorithm can find more similar pictures." (Participant B4Post)

This reflects the limitations of collaborative ideation with image-generative AI and provides generalized data. Computational AI systems lack emotional abilities and their artistic abilities require academic attention [75]. Participants were able to collect information based on their aesthetic identity using the previous method; however, when using the AI platform, the mechanically synthesized or derived results

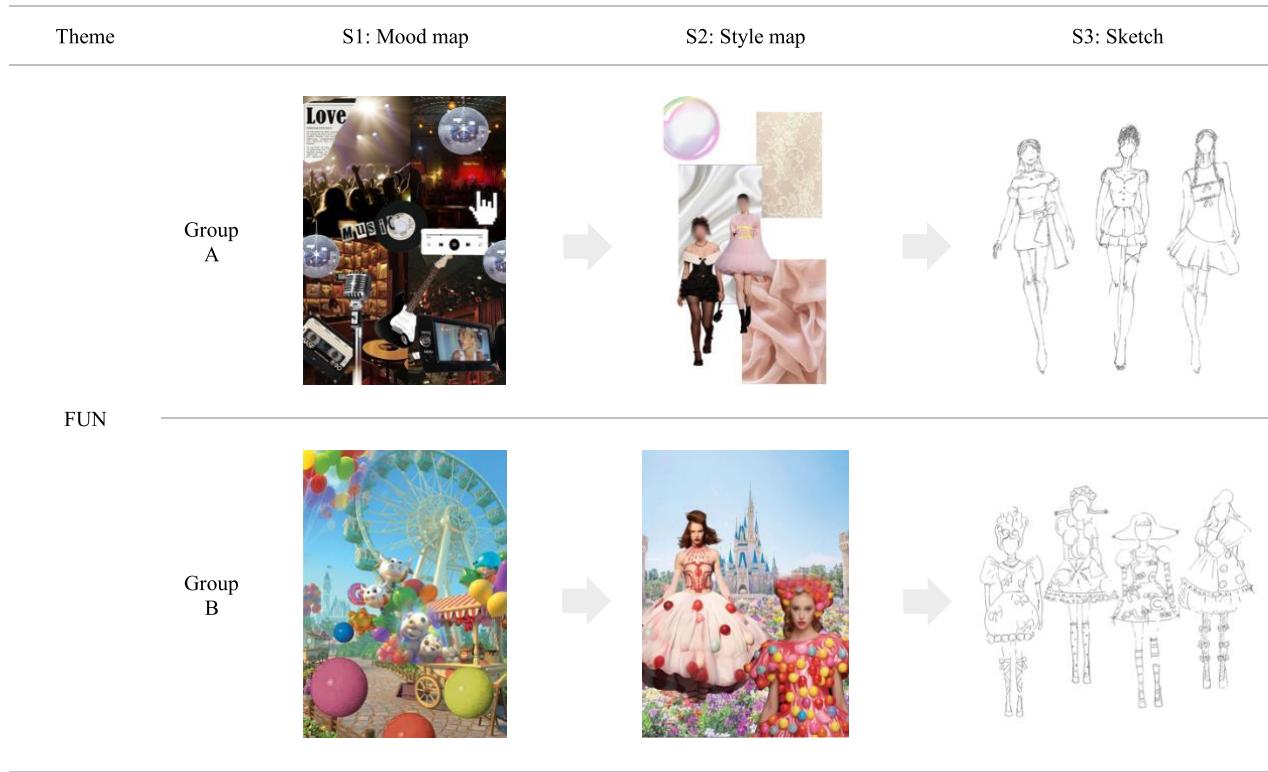


FIGURE 1. Comparison of participants' results in each session.

did not reflect their tastes (even if they entered it as text). Thus, it was not related to their intentions. They observed that only visual materials that did not exist were being created. Brand identity, designer taste, sociocultural context, and professional knowledge are comprehensively reflected in the fashion ideation process [76]. However, in collaborative ideation with AI, the opportunity for designers to participate is reduced.

AI-generated images that deviate from human common sense have the opposite effect of providing a stimulating opportunity for users to generate unique ideas as they obscure interpretation. This is related to the possibility of creativity. Regarding collaborative ideation with AI, some participants explained that they were able to obtain more novel and satisfactory results when they created images by entering specific images and prompts, rather than using the existing keyword search method.

“Using specific reference photos for input yielded interesting results, which was enjoyable. I had difficulty creating prompts, so I used a translator to input them. I could obtain images closer to my thoughts and it turned out more unique than when I didn’t use it.” (Participant B5Post)

In summary, despite the limitations of not reflecting individual characteristics and the potential to produce ordinary results, collaborative ideation with AI, without considering any differences in expertise, provides outcomes based on a database that transcends the boundaries of fashion and

sociocultural aspects. The results may exhibit the creative attributes of originality and fluency, which can be perceived as novel in fashion.

S2: Although additional refinement was required, participants obtained novel results and new ideas through collaborative map creation with AI compared to working alone.

“When creating collages with images, I found it most satisfying. The results were realistic and the immediate and quick production was enjoyable. The temporal efficiency allowed for more diverse thinking.” (B4Post)

“I did some reworking with Photoshop, but I didn’t have to search for each item individually, so it was very effective, both in terms of time and quality. Also, the sketches that AI directly drew seemed like something in my mind but a bit unclear. It made me feel like I could see them more clearly.” (Participant B1Post)

In independent ideation, creating a fashion style map requires techniques to collect and synthesize all sources. Various simulations are performed and ideas are generated during the process. However, collaborative ideation reduces the time required to handle graphics programs and helps achieve intuitive image thinking. In other words, given the nature of the fashion industry, which requires quick judgment and several ideas in a limited time, collaborative ideation with AI shows the creative attributes of flexibility and fluency. Participants explained that in this collaborative

TABLE 2. Comparison of creative properties of fashion ideation between the two groups.

Attributes	Session 1		Session 2		Session 3	
	Group A	Group B	Group A	Group B	Group A	Group B
Sensitivity	Collection of images reflecting fashion design experience					
Abstraction	Connecting ideas with personal aesthetic experience and identity		A visual combination that reflects personal style preferences			
Uniqueness	Approaching ideas beyond the scope of personal experience		Combining the fashion field with other fields that you have no experience with			
Fluency	Infinite creation of a variety of visual materials that go beyond physical reality		Various combinations of elements that go beyond understanding in a short period	Design expression based on collected images and personal experiences	Various applications of visual elements using AI images	
Flexibility			A shift in thinking through the natural expression of unexpected combinations			
Sophistication				Various modifications and expressions of design based on production experience	Expression of clothing composition that has not been experienced before	
Reconstruction			Creation of unexpected ideas through organic combination of different sources			

idea, collages enabled more original and natural expressions than independent ideas. AI-generated images have emergent properties in that they learn data from existing works of art and combine them with new images [77]. These attributes create a unique experience in which users feel heterogeneity by expressing familiar things in an unfamiliar but natural way. This can be related to flexibility, which changes fixed perspectives and quickly changes thinking.

S3: Collaborative ideation with AI and independent cases showed similar results. The participants explained that AI-generated images helped concretize ideas and expression techniques.

“Drawing detailed aspects can be challenging, even when looking at actual photos. Since the goal is to derive a design

that I desire rather than merely referencing existing photos, it helped draw with guidance.”

This indicates that collaborative ideation with AI can enhance expressive skills, particularly for fashion students who lack confidence in drawing skills. This relates to the creative attributes of sophistication, which enable a detailed representation of abstract ideas.

However, some participants, using the AI platform, explained that the results closely resembled their original ideas, appearing realistic. This sometimes leads to a diminished sense of the need for sketching. Furthermore, it provides a source for expanding ideas and offers opportunities for better sketch outcomes.

“I input commands along with images to obtain the output of the model wearing a fashion style, and the quality was so

TABLE 3. Evaluation of participants' creations in each session.

		Session 1					Session 2					Session 3						
Group		OR	DS	AE	HR	DE	NE	SV	SO	OR	US	AC	NE	SV	SO	OR	US	AC
A	avr	4.6	4.3	4.5	4.9	4.4	4.0	4.1	4.1	4.1	4.3	4.7	3.7	3.8	4.3	3.9	3.8	4.4
	sd	1.1	1.2	1.1	1.2	0.8	1.4	1.3	1.4	1.4	1.0	1.4	1.4	1.3	1.5	1.5	1.3	1.1
B	avr	4.9	4.7	4.8	4.7	4.8	4.9	4.6	4.7	5.1	4.1	5.2	5.1	4.3	5.1	5.4	4.1	5.2
	sd	0.9	1.3	1.0	1.1	1.6	0.9	1.1	0.9	0.8	0.9	0.9	1.2	1.2	1.1	1.0	1.1	1.3
A-B	avr	-0.3	-0.3	-0.3	0.2	-0.4	-0.9	-0.5	-0.7	-1.0	0.3	-0.5	-1.4	-0.5	-0.8	-1.5	-0.3	-0.8
	sd	0.2	-0.2	0.0	0.1	-0.8	0.4	0.1	0.5	0.6	0.2	0.5	0.2	0.1	0.5	0.5	0.2	-0.2

good that I didn't feel the need for sketching." (Participant B1Post)

"While sketching, it's easy to draw right away for the first outfit, but as you go on, the designs become similar, and it gets a bit disappointing, and my drawing slows down. However, since various images were presented earlier, and seeing these inspired me, I could expand my ideas and draw more." (Participant B5Post)

Participant B5 submitted their results to the other participants. After synthesizing the responses, the findings indicated that previously generated AI images assisted the conceptual aspect of ideation using sketches. While demonstrating proficiency in generating numerous ideas within a limited timeframe, this suggests a potential reduction in the role of sketches traditionally employed in design ideation. Figure 1 and Table 2 compare the creative attributes of the independent and collaborative groups in each session.

C. EVALUATION OF CO-CREATION

The results of experts' Likert-scale-based evaluation of participants' results generated in each session are summarized in Table 3. Throughout the sessions, Group B showed higher average scores for most creativity aspects than Group A, and the standard deviation was relatively low. Conversely, specific attributes showed higher average values for Group A for harmony in S1 (A-B, avr.: 0.2) and usefulness in S2 (A-B, avr.: 0.3). Notably, despite the use of the same tools (pencil and paper) in S3's sketching session, a pronounced difference in results between the two groups was observed. Among the attributes of originality (A-B, avr.: -1.5) and newness (A-B, avr.: -1.4), Group B exhibited the most significant deviation. A comparison of the standard deviations indicated consistently lower values in Group B.

Computer-generated images often result in profound and surprising forms, and suddenly an entirely unexpected image appears [47]. This is because co-creativity creates boundaries and inspiration among collaborators. It acts as a means of giving, and the complementary and unexpected contributions of collaborators can serve as a force to elevate the results beyond each individual's capabilities [78]. Therefore, collaborative ideation with AI in the fashion design process has the potential to influence the overall improvement of creative attributes among participants.

V. CONCLUSION

A. DISCUSSION

Inspiration sources are diverse and play a leading role throughout the design process [55]. Creativity is a natural human attribute that can be developed and nurtured [35]. Image thinking influences the creativity of designers, whereas human creativity is influenced by the environment. This study explores the impact of collaboration with AI on fashion ideation from the perspectives of image thinking and creativity. In the fashion ideation process, fashion students demonstrated expansive image thinking in the perceptual awareness of formal elements, such as color and form. They showcased convergent image thinking by organically combining various ideas within a limited time. In contrast, collaborative ideation with AI revealed expansive image thinking, exploring visual extensions, and convergent image thinking, resulting from a lack of sociocultural understanding and a combination of ideas lacking individual identity. Reddy [38] highlighted potential limitations in algorithmic creativity, requiring critical interpretation when dealing with errors or controversial information. The need for a nuanced approach, tailored to the levels of students and the expertise of designers, was emphasized. Therefore, it can have ambivalence as an educational tool (e.g., design fixation vs. sociocultural prejudice).

Collaborative ideation with AI exhibited distinctive creative attributes compared with the control group. Traditional fashion ideation involves sensitivity, abstraction, and reconstructive creative attributes. In contrast, collaborative ideation with AI encourages originality, fluency, and flexibility. Similarly, the outcomes of collaborative ideation with AI demonstrated higher creativity in terms of originality and novelty. These results suggest that the application of emergent properties, where AI models learn from existing artistic data to generate new images, contributes to this phenomenon [77].

Kim and Maher [41] elucidate the impact of AI models inspiring based on conceptual similarities, which aligns with our findings. AI models influence the freshness, diversity, and quantity of ideas in human design by leveraging conceptual similarities [41]. However, our study did not identify abstract creativity or the ability to generate new ideas based on past experiences [66] during collaborative ideation with AI. This implies that the AI platform used in this study may not provide the specialized data required for creativity in fashion.

Considering the distinctive characteristics of the fashion industry, Ruppert-Stroescu and Hawley [45] divided fashion creativity into leadership and adaptive creativity. They explained that the sources of inspiration were different, with abstract primary sources not directly involved in the product, while secondary sources reproduced the product or design. They highlighted that their sources of inspiration were different. Although AI-generated images may not perfectly reflect the intricacies of fashion, they can contribute to expansive and emergent image thinking, thereby, supporting abstract and original fashion ideation. Even if lacking adaptive creativity, AI collaboration can extend the vision of leadership creativity in innovative fashion designs.

The results suggest that collaborative ideation with AI in fashion design education must be approached in two dimensions: formal tools, such as graphic tools, and content tools. In terms of form, it can expand fashion students' perspectives and improve their overall creativity. In the process of co-creating fashion images with AI, they repeatedly interacted with the AI platform, and AI-generated images, that exceeded human sociocultural categories, provided opportunities to expand their recognition. The artifacts showed higher levels of novelty and originality than the other groups. In particular, S3, using sketches in which no differences in creative attributes were found between the two groups, is noteworthy. This result is similar to Lim et al. [18] who conducted an exploratory experiment that positioned AI as a relational artifact in drawing activities and found that the results between AI and students did not show a dramatic difference in creativity. These results suggest that the method of collaborative ideation with AI may not show a significant difference in creative results, however, has the potential to supplement the creative attributes that the previous method lacked in the process.

This study found that the results of collaborative ideation with AI differ depending on the level of skill and do not sufficiently reflect individual aesthetic tastes. Since various factors, such as aesthetic presence, psychological satisfaction, and social attitude, play a role in fashion ideation [79], it is necessary to recognize and approach it as an auxiliary tool, rather than relying on image-generative AI in a collaborative relationship.

The process of collaborative ideation with AI can be discussed based on students' digital literacy ability. In a study of prospective teachers, Vartiainen and Tedre [16] pointed out that collaborative production with image-generating AI tools can create a critical discourse on craft education. For example, AI images lead to data-driven decisions, raising new concerns, such as power relations, algorithmic bias, and hybrid impacts [60], [80], [81], [82], [83]. Throughout the interview process, participants experienced confusion due to copyright issues and the derivation of images that were different from cultural or historical facts. They expressed concerns that deep thinking opportunities were reduced due to automatic image creation. In light of the emergence

of concerns about inconsiderate cultural appropriation and copyright within the fashion industry [83], these issues must be considered. This implies the need to foster the ability to critically interpret AI-generated images. This can be achieved by developing educational models [18] that encourage humans to collaboratively improve each other's creative generation using AI in a changing environment.

B. SUMMARY AND LIMITATIONS

This study explored the impact of image thinking and creativity on the fashion ideation process, using image-generative AI. This study sought to explore the capacity of GAI to enhance creativity during the ideation process within the design domain. Specifically, it compared the use of GAI by fashion students throughout the fashion design development process against a control group. Interviews and analyses of participants' creations were performed to identify differences in image-based thinking and creativity between the two groups. The findings are detailed below. First, although model development using AI focuses on productivity and efficiency, approaches to its impact on human perception and thinking are insufficient. The research results contribute to establishing the relationship between the role of humans and AI in the collaborative fashion design process. This has academic significance in narrowing the research gap with AI technology in the arts and social culture fields. In addition, if the results are applied to educational programs based on fashion ideas, it will pre-emptively identify and respond to the impact on the fashion industry and education. If the roles between parties required in the collaborative process are applied to the fashion industry, it will contribute to the formation of a new fashion ecosystem by reducing unnecessary energy consumption and the efficient use of resources and simulation.

The results also indicate that establishing an effective collaborative relationship with GAI during design ideation and development necessitates the implementation of sharing mechanisms and a comprehensive description of the process. Participants employed Midjourney in an iterative process to generate images, underscoring that AI outcomes often depend on chance, which complicates the prediction of results. For AI to significantly contribute to human decision-making, transparency and validity are crucial, as outlined in the OECD AI Principles [90]. Recent studies on explainable AI have predominantly concentrated on the application of machine learning processes to create interpretable models and techniques. However, there is an urgent need for explanations that are accessible to designers and students across varying expertise levels. This study underscores the importance of developing a GAI model capable of elucidating the utilization of prompts within the fashion design development process for both the industry and educational sectors, including the relationship between these prompts and the resultant designs.

Nevertheless, this study has the limitation of focusing only on text-to-image generative AI tools. Applying various AI

collaborative tools to fashion ideation (e.g., text, drawing, or style creation) can provide new insights. This investigation centered on assessing the potential impact of AI tools on fashion students, employing a qualitative research methodology with 10 participants. To broaden the applicability of the results, future studies should integrate quantitative research methods to encompass a more extensive participant base.

In addition, a designer's creative process has a significant impact on the individual's a priori knowledge [84], [85], and the designer's expertise influences the process of finding inspiration [86]. Therefore, this study, targeting students who used the AI platform for the first time, may have resulted in differences in the research results depending on their level of proficiency. Since this study did not sufficiently consider the environmental impact of each research participant and the difference in knowledge between students and professional designers, future research should consider more specific differences by focusing on the understanding of generative AI tools, gender, lifestyle, and the experience of the practitioners.

ABBREVIATIONS

AC:	Attractiveness.
AE:	Appropriateness of expression.
AVR:	Average.
DE:	Detail of expression.
DS:	Diversity of source use.
HR:	Harmony.
NE:	Newness.
OR:	Originality.
SD:	Standard deviation.
SO:	Sophistication.
SV:	Solvency.
US:	Usefulness.

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