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AI tools and fashion design education: instructor perspectives on student challenges and design process tool support

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Abstract

Despite growing interest in artificial intelligence (AI) in higher education, research on its pedagogical integration in fashion design education remains limited, with most studies focusing on the technical aspects of AI tools rather than their instructional roles or educational implications. This study explores how AI tools can be effectively integrated into fashion design education by examining student challenges, AI-supported learning competencies, and instructional considerations from the perspectives of instructors. Semi-structured interviews were conducted with 10 university-level instructors from South Korea and the United States who have experience teaching fashion design-related courses. Thematic analysis is employed to examine the educational roles of AI in supporting students across the various design process stages. Findings identify four primary areas where students commonly face difficulties: initial design planning, ideation and creative exploration, technical garment construction, and communication and feedback adaptation. This study presents a pedagogical framework that illustrates how AI tools, including large language models, image generators, simulations, and feedback systems, can enhance visualization, creative thinking, and student engagement. This framework aligns student challenges, AI tool functionalities, and instructional strategies across four stages of the design process—problem definition, ideation and refinement, prototype development, and evaluation—offering practical guidance for the intentional integration of AI in fashion design education that promotes learner autonomy and human–AI collaboration.

Keywords: Artificial intelligence, Fashion design education, Design process, Higher education, Student challenges

Introduction

Against the background of rapidly evolving technologies and shifting pedagogical paradigms, higher education faces increasing pressure to innovate teaching and learning practices. Among the most transformative developments is the integration of artificial intelligence in education (AIED), which is reshaping the roles of learners, instructors, and institutions. AIED encompasses a range of technologies, such as adaptive learning systems, automated assessment tools, and learning analytics platforms, which support personalized, data-driven, interactive instruction across disciplines. Importantly, AIED

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not only facilitates content delivery but also promotes learner agency, reflective thinking, and collaboration between humans and machines. Through its Digital Education Action Plan 2021–2027, the European Union promotes understanding of AI and supports the adoption of new teaching and learning methods. Similarly, the Korean Ministry of Education has announced the First Comprehensive Plan for Information Education, emphasizing the cultivation of AI experts and the growing need for AI-integrated education to foster convergence competencies in higher education (Korea Research Institute for the Future, 2024). Consequently, instructors are encouraged to reexamine conventional instructional methods and assessment strategies (Heredia-Carroza & Stoica, 2024).

In design education, AI tools are increasingly integrated into both visual and analytical tasks. These tools support students in managing large volumes of information and serve as a complement to traditional, hands-on design methods. Grájeda et al. (2024) demonstrate that AI enhances student comprehension, creativity, and productivity in higher education. Despite these benefits, their Synthetic Index of Use of Artificial Intelligence Tools indicates that adoption rates in the arts are significantly lower compared to engineering and business, highlighting a need for awareness and support in design disciplines. Historically, human designers have primarily driven ideation and problem-solving through individual judgment. Recently, however, AI has emerged as an active co-creator, shifting the designer's role toward sensemaking—determining which problems are worth addressing (Verganti et al., 2020).

Within fashion design education, the adoption of AI tools is becoming increasingly prominent. Prior studies emphasize their potential to foster creative thinking and enhance technical skills (An & Park, 2021, 2023; Lee, 2020). Fashion curricula are generally designed to build student competencies across the stages of the design process, including inspiration, identification, conceptualization, exploration and refinement, modeling, communication, and production (Aspelund, 2014). While AI tools are increasingly adopted in fashion design education, their distinct pedagogical roles throughout the design process remain underexplored. Most prior studies in this field actively explore the technical or creative potential of AI (Kang et al., 2024; Park et al., 2025; Suvarna & Balakrishna, 2024), yet pay relatively little attention to its educational functions or the institutional challenges of curricula integration. Specifically, few specifically examine how instructors perceive AI and use it to support student learning or how such tools can be meaningfully aligned with instructional objectives. This leaves a critical gap in understanding the pedagogical mechanisms that enable systematic integration of tool types, instructional goals, and teaching approaches into fashion design education. By examining instructors' perspectives, this study seeks to fill this gap by highlighting the educational value of AI tools and outlining strategies for their effective implementation.

Ouyang and Jiao (2021) argue that to fully support learner agency and personalized learning, AIED must align with the experiences and perspectives of educational stakeholders. In fashion design, instructors are aware of the difficulties students face at each stage of the design process (Asemsro & Obinnim, 2020). Building on this insight, the present study aims to categorize these student challenges, explore how AI tools may address them, and identify strategies for their practical integration. Ultimately, it seeks to advance AIED in fashion design education by proposing a pedagogical framework that connects student needs, AI tool functionalities, and instructional strategies.

Literature Review

AIED

Higher education in the twenty-first century faces dynamic challenges, prompting continuous shifts in teaching and learning paradigms. AIED encompasses a range of education technology and technology-enhanced approaches that support instruction, assessment, and learner analytics across disciplines (Alam & Mohanty, 2023). AIED promotes practical competencies by helping students understand core AI concepts and apply them within instructional contexts (Yang & Bai, 2020). However, the aim of higher education extends beyond information transmission or monitoring; it is fundamentally about expanding cognitive capacities and improving the quality of learning (Popenici & Kerr, 2017).

Holmes et al. (2019) distinguish between two educational approaches to AI: learning about AI and learning with AI. The former focuses on understanding AI principles, while the latter refers to using AI as a system that supports both students and instructors. Ouyang and Jiao (2021) classify the evolving relationship between AI and learners into three paradigms: AI-directed (learner-as-recipient), AI-supported (learner-as-collaborator), and AI-empowered (learner-as-leader). The AI-directed paradigm guides cognition and the learner follows structured knowledge sequences, which is less effective for ill-defined or creative tasks (Pinkwart, 2016). The AI-supported paradigm involves interactive learning, where AI supports active engagement by integrating learner data and offering real-time decision-making opportunities. The AI-empowered paradigm emphasizes learner autonomy, with AI acting as a cognitive enhancer in a system of synergistic collaboration among learners, instructors, content, and technologies (Riedl, 2019). Under the AI-empowered model, AI does not replace the roles of learners or educators but serves as an integrated element in a broader learning ecosystem. Learners are encouraged to develop reflective learning strategies while managing the risks of AI-driven decision-making. Educators use AI's personalized and interpretable outputs to promote learner-centered instruction (Holmes et al., 2019). Ultimately, AIED is advancing toward models of personalized and adaptive learning, characterized by human–computer collaboration.

The potential of these paradigms is tempered by technological and ethical challenges. Rodway and Schepman (2023) identify key concerns in the AIED risk framework, such as misalignment of pedagogy, misuse of AI tools, issues of accountability, privacy, security, transparency, perceived bias, and misinterpretation of human-centered AI. These risks must be considered throughout the design and deployment of AI systems (Yang & Evans, 2019), along with practical challenges such as financial costs (Zhang & Aslan, 2021) and data privacy (Zhang & Dafoe, 2019).

Castañeda and Selwyn (2018) argue that the mere use of AI does not guarantee educational value. Meaningful integration requires pedagogical transformation that shapes both quality of education and learner experience (Hwang et al., 2020). In fashion design education, this highlights the importance of developing AIED-based frameworks that embed AI tools into curricula and strengthen students' practical and design competencies.

Fashion design competencies and process-based education

In both educational and industry contexts, the development of fashion design competencies is guided by occupational standards that shape curriculum design. For instance, countries such as the United Kingdom, Germany, and Canada employ National Occupational Standards to define essential skills, including concept development, garment structure knowledge, design development, proper documentation, and selection of appropriate materials and trims (UK Standards, 2013). Similarly, Korea's National Competency Standards outline skillsets such as planning, material analysis, prototype development, and evaluation (Korea Industrial Human Resources Corporation, 2016).

University curricula align with these competency units through courses such as fashion aesthetics, design history, design development, fashion illustration, and portfolio preparation, thereby enhancing students' industry readiness. Fashion design education also emphasizes a process-based approach to problem-solving. Various models have been proposed to guide this pedagogy. Watkins (1995) outlines a sequential process—accept, analyze, define, ideate, select, implement, and evaluate—emphasizing iterative development and encouraging students to formulate their own projects and apply both analytical and intuitive strategies. LaBat and Sokolowski (1999) propose a design model tailored for collaboration between academia and industry, dividing the process into problem definition and research, creative exploration and development, and implementation. Lamb and Kallal (1992) introduce the apparel design framework, which considers cultural context and user needs across six stages: problem definition, preliminary ideas, design refinement, prototype development, evaluation, and implementation.

Previous studies identify common approaches to defining and solving design problems, highlighting the importance of research, sketching, and experimentation in fostering creative problem-solving among fashion designers (Laamanen & Seitamaa-Hakkarainen, 2014). The clothing design process is directed toward teaching applications, and adherence to this process provides students with the confidence and tools needed to complete their assignments (Orzada & Kallal, 2021).

AI tools in fashion design education

AI tools refer to software applications that utilize AI algorithms to solve specific problems or perform tasks (Gil de Zúñiga et al., 2024). In educational settings, such tools help students collect and analyze data efficiently, enabling them to focus on higher-order cognitive tasks such as inference and prediction, rather than on repetitive or routine work (Hwang et al., 2020).

In fashion design education, digital technologies have long supported designers in exploring problems and generating creative solutions. Prior research on the application of AI in fashion education suggests two primary areas of use. The first involves the visualization of abstract concepts. For instance, Lee (2020) employs a neural network-based tool, the Deep Dream Generator, in conjunction with augmented reality to support students work in fashion drawing, textile development, texture creation, and mood board composition. Similarly, AI image-generation platforms such as Midjourney, DALL·E 2, and Stable Diffusion allow users to visualize transformation, translation, and expansion based on text prompts (Park & Han, 2023). These tools

employ advanced generative models, including generative adversarial networks, to enable the reconstruction, alteration, or expansion of fashion image elements (Choi et al., 2023). The second area concerns quantitative problem-solving through big data analysis. Jeon et al. (2021) introduce an AI-based Creativity Support Tool (CST) to the fashion ideation process, which fosters both divergent and convergent thinking. The CST helps students overcome design fixation, a state in which designers unconsciously limit their creative exploration due to prior experiences or assumptions (Crilly & Cardoso, 2017), by using big data and computational power to search for novel ideas and receive feedback. Building on this concept, An and Park (2023) apply the CST to practical coursework, guiding students to construct a fashion product database for supervised learning, analyze trending design elements quantitatively, and integrate those insights into their design development.

These studies demonstrate that AI tools can support various aspects of students' practice in fashion design education. Nevertheless, the diversity of learning challenges and instructional approaches across courses makes it difficult to generalize integration strategies. There remains a need to clarify the roles of different AI tools within the design process and to develop tailored guidelines that align their capabilities with pedagogical goals. In this context, the present study draws attention to the intentional integration of AI tools—an approach that situates their use within instructional objectives and student learning needs—and suggests that their support should be mapped to the stages of the design process in ways that enhance student competencies at each step.

Methods

Research design

This study adopts an exploratory qualitative design to investigate effective strategies for integrating AI tools into fashion design education. Recognizing the diversity of learning challenges and instructional practices across courses, the research specifically seeks to map the support provided by AI tools to distinct stages of the design process and identify how such tools can enhance student competencies at each stage. Grounded in a process-based understanding of fashion design education, this study focuses on clarifying the pedagogical roles of AI in addressing student challenges and promoting problem-solving at different stages of the design process (Fig. 1). The research is guided by the following questions:

RQ1. What key challenges do students face during the fashion design process?

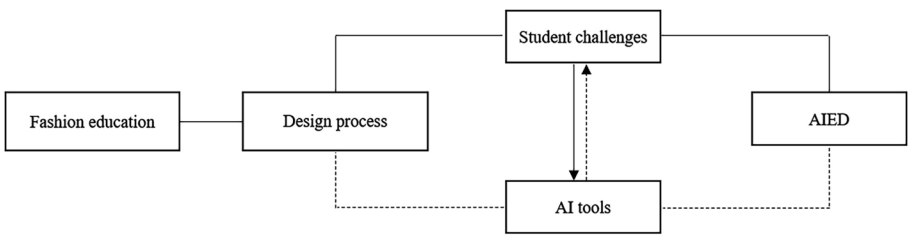


Fig. 1 Conceptual model linking student challenges, AI tools, and AIED across the design process

RQ2. How can AI tools support students in solving problems and enhancing competencies within the design process?

RQ3. What instructional strategies are effective for implementing AIED in fashion design?

Participants

This study received approval from the Institutional Review Board (IRB) of the affiliated university (IRB No. 2-1040766-AB-N-01-R-2024-02), and only instructors who provided informed consent participated in the research. Prior studies have demonstrated the effectiveness of small-scale qualitative research involving instructors in the field of educational research. In relatively homogeneous populations, such as instructors within a specific discipline, data saturation can be reached with a small sample size (Hennink et al., 2020). Moreover, several studies have reported that in-depth interviews with fewer than 10 participants can yield rich and meaningful insights, particularly when the goal is to develop instructional guidelines for technology integration (Alvarez & Urla, 2002; Pathak & Intratat, 2012). Drawing on these precedents, this study selected 10 participants, balancing depth of inquiry with considerations of time and resource constraints.

Participants were purposefully selected through professional email outreach and snowball sampling (Noy, 2008; Patton, 2014). Initial contact was made with instructors known to engage in technology-enhanced fashion design education or related research based on publicly available contact information on university websites. Eligible participants were university instructors who had taught courses covering one or more key stages of the fashion design process. The sampling aimed to include both experienced instructors (with more than 5 years of teaching experience) and early-career instructors with practical experience using AI tools, while also ensuring diversity in teaching backgrounds, subject areas, age, and institutional affiliation. Instructors from South Korea and the United States were included to capture perspectives from two higher education contexts that are both active in AI integration yet differ in institutional and cultural approaches to design pedagogy. Although efforts were made to recruit participants from both countries, accessibility constraints led to a sample weighted toward South Korea, comprising eight instructors from South Korea and two from the United States. This composition nevertheless allowed for comparative insight into how contextual factors shape AI adoption in fashion education. Since all participants were proficient in Korean, interviews were conducted without the need for translation, and transcription and analysis were performed in the original language. The analysis was carried out with careful consideration of the cultural and institutional contexts involved (Table 1).

Data collection

Semi-structured, in-depth interviews were conducted to elicit open and experience-based responses from participants. Participants were fully informed about the purpose and scope of the study prior to the interview and provided with a summary of AI tools commonly used in fashion design education, such as Midjourney, DALL·E 2, CST, Deep Dream Generator, and Artbreeder. Participants were encouraged to explore these tools before the interview. For CST, which had limited accessibility, a pre-recorded video

Table 1 Demographic characteristics of participants

No	Title	Education	Age	Experience (year)	Institutional location	Teaching subjects
P1	Instructor	PhD	44	10	Chungbuk	CLO 3D, CAD, fashion design, fashion illustration, garment construction, etc
P2	Instructor	PhD	40	5	Daegu	CAD, portfolio, textile design, etc
P3	Instructor	PhD	41	9	Seoul	Fashion color and expression, fashion design analysis, etc
P4	Instructor	PhD	40	10	Seoul	Color and fashion styling, fashion illustration, fashion design, etc
P5	Instructor	PhD	46	15	Seoul	Fashion design studio, fashion illustration, technical drawing, etc
P6	Professor	PhD	38	1.5	Oklahoma	CAD, fashion accessories, pattern making, etc
P7	Instructor	MS	39	6	Hwaseong	Knitwear accessories development, fashion trend analysis, etc
P8	Professor	MS	42	10	California	CAD, fashion collection, creative design, fashion design, portfolio, etc
P9	Instructor	MS	40	12	Seongnam	3D design, fashion illustration, pattern making, history of costume, etc
P10	Instructor	MS	44	15	Seoul	Design thinking, fashion illustration, technical drawing, pattern making, etc

tutorial was provided instead. All participants entered the interviews with a foundational understanding of the tools and their educational applications.

Interviews were conducted individually via online sessions between July and October 2024, each lasting approximately one hour. Open-ended questions were used to elicit detailed responses, and data collection continued until thematic saturation was reached (Roulston, 2001). Given that one of the researchers was professionally engaged in fashion design education, reflexivity was maintained throughout the process to mitigate potential biases associated with insider positionality. When participants expressed familiarity with the researcher's background (e.g., "Why ask when you already know?"), efforts were made to underscore the value of their unique experiences and elicit richer narratives. This deliberate distancing aimed to reduce any risk of preconceived assumptions or interpretive bias. All interviews were audio-recorded with the participants' prior consent.

The interview instrument comprised eight open-ended questions divided into four main sections. The first section included questions regarding participants' educational background in fashion design, along with demographic information such as age, institutional location, subjects taught, years of teaching experience, and current professional status. The second section focused on the challenges that students encountered during class and the extent of instructional support provided by educators. The third section explored the supportive functions of AI tools in educational contexts, while the fourth section addressed strategies for integrating AI tools into education.

The interview instrument was designed to begin with general questions related to fashion design students and gradually focus on AIED, following Sommer and Sommer's (2002) recommendations. The questions were developed from both the literature and the researchers' experiences. Two questions were created based on studies regarding the design process

(Lamb & Kallal, 1992): "What challenges do students face during the fashion design process?" and "How do instructors help students with these problems?" Next, questions about respondents' experiences with AI tools were inspired by Ouyang and Jiao (2021), addressing AI's role and its impact on learners, including, "What specific tasks in fashion design can AI tools support?" and "What student skills can be strengthened through the use of AI tools?" The various concerns raised by Rodway and Schepman (2023) about the misalignment of AI pedagogy, misuse of AI resources, accountability risks, and privacy and security concerns led to the development of questions on AI integration strategies, such as "How can fashion design education be effectively integrated to AI technology" and "What are the positive and negative impacts of AI technology in fashion design education?".

Data analysis

The data were analyzed using Braun and Clarke's (2006) thematic analysis method. This widely adopted approach in qualitative research was suitable for the study as it allowed for a systematic identification and interpretation of both explicit and implicit meanings within the data, resulting in themes, defined as patterns of shared meaning underpinned by core concepts.

The analysis followed six phases: familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. Recorded verbal data from participants were transcribed into text using ClovaNote, a voice recognition transcription service. To ensure interpretive accuracy, member checking was conducted with participants (Lloyd et al., 2024; Strauss & U, 2007).

Data coding was conducted using the ATLAS.ti software program (Version 25; Bhattacharya, 2015). The researchers repeatedly read the transcripts, highlighted meaningful content relevant to the research questions and literature, assigned preliminary headings, and organized these into coding sheets to generate initial codes and themes (Burnard, 1991). To reduce any possible confounding element introduced by the researchers' experience or judgements, two researchers independently coded the data and compared their coding, creating the pre-determined coding frame, and discussed new codes and meanings, while negotiating any disagreements. Codes and themes that emerged continued to be refined and integrated throughout the process. Ultimately, the researchers achieved an intercoder reliability rate of 96.6%, surpassing the suggested levels of Creswell and Poth (2016). The data were coded into categories aligned with the research questions and categorized into three main areas: (1) student challenges in fashion design, (2) AI tool-supported competencies in fashion design, and (3) considerations of AIED in fashion design. Each theme/sub-theme was named and analyzed based on the frequency of relevant sentences or phrases (Collingridge, 2013; Table 2). A set of key themes and representative quotations for each theme were tracked. Figure 2 presents the data analysis process of this study, incorporating triangulation to enhance validity.

Results

Student challenges in fashion design

The difficulties encountered by students in fashion design are closely related to the design task stages proposed by LaBat and Sokolowski (1999) and Lamb and Kallal (1992), which include problem definition, preliminary ideas, design refinement,

Table 2 Categorized themes and sub-theme frequencies identified from instructor interviews

Categories	Theme	Sub-theme (frequency)
Student challenges in fashion design	Initial design planning difficulties	Defining a design concept (33) Selecting concept-relevant sources (18) Brainstorming initial ideas (17) Using limited research channels (8) Finding raw design source (4) Setting a target market (4)
	Ideation and creative exploration barriers	Insufficient design variations (19) Translating ideas into design elements (14) Image mapping (12) Design decision-making (12) Design ideation within a concept (7) Technical and aesthetic expression of design ideas (9) Reduced creative exploration due to workload (4)
	Technical design and garment construction challenges	Creating accurate technical drawing (21) Making pattern and sawing (13) Managing production time (8) Using practical terminology (5) Understanding garment structure (2)
	Communication and feedback adaptation issues	Engaging in public speaking (7) Interpreting and adapting feedback (3)
AI tool supported competencies in fashion design	Design generation and creative visualization	Prompt-to-image (26) Prompt-to-sketch (23) Realistic image generation (20) Virtual simulation (6)
	Design refinement and visual modification	Image refinement (40) Image merging (30) Body pose adjustment (14)
	Design optimization and data-driven decision-making	Search and organize data (16) Data-driven decision making (8) Design validation (6) Portfolio layout recommendation (3)
Considerations of AIED in fashion design	Pedagogical integration of AI	Process-based qualitative assessment criteria (26) Interactive learning with AI and instructors (18) Independent AI use for advanced students (17) Foundation knowledge building (16) Prompt and terminology training (14)
	Ethical and learning risks	Recognizing AI designs as student original (51) decline in student effort (39) Over-reliance on AI (7)
	Technical constraints of AI tools	Uncontrolled random AI output (24) Low-quality output (18) Limited functionality of 3D pattern assistant (6)
	Institutional and resource barriers	Paid access requirement (12) Lack of suitable courses (6) Equipment requirement (4) Lack of AI-competent instructors (1)

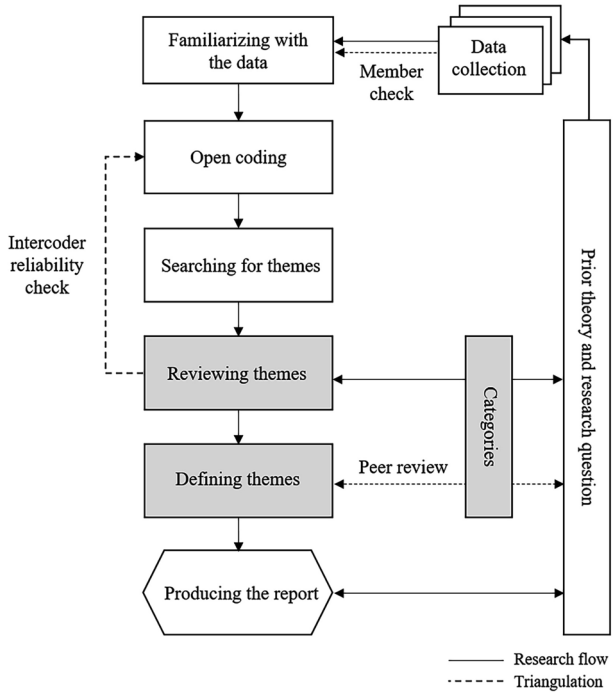


Fig. 2 Data analysis process

prototype development, evaluation, and implementation. Students' challenges were categorized into four themes: (1) Initial design planning difficulties refer to the confusion and uncertainty experienced when defining the design problem and establishing the direction of the project; (2) Ideation and creative exploration barriers involve constraints in expanding creative ideas; (3) Technical design and garment construction challenges reflect students' limited technical skills and difficulties in translating design ideas into physical garments; and (4) Communication and feedback adaptation issues encompass challenges in exchanging ideas with instructors or peers, and incorporating feedback effectively into the design process.

Initial design planning difficulties

Most instructors (9 out of 10) reported that students experience significant difficulties during the early stages of the fashion design process, particularly in brainstorming diverse ideas and defining a clear design concept. These challenges often arise when students have not gathered sufficient reference materials. Specifically, instructors reported that students often struggle with the research phase due to their limited approach to sourcing, often relying exclusively on a narrow range of platforms such as Pinterest. Additionally, they perceived challenges in collecting raw, unprocessed materials rather than curated or completed designs created by others. Instructors also perceived difficulty in identifying and selecting high-quality, conceptually relevant references that can effectively support the development of a unique design concept.

Ideation and creative exploration barriers

LaBat and Sokolowski (1999) defined creative exploration in fashion design as the process of breaking away from habitual thinking to form new design ideas. Nine out of 10 instructors reported that students often struggle with design ideation within a defined concept. Specifically, students faced challenges in selecting appropriate motifs, materials, and colors that aligned with their intended concept, and they often felt uncertain when arranging visual materials, such as collected images, during the image mapping process. Consequently, many students relied on instructors for guidance and decision-making at this stage. Instructors noted that students tended to fall back on familiar ideas rather than taking creative risks, particularly when translating abstract concepts into tangible design elements such as garment details, textures, or silhouettes. A hesitant attitude toward stepping outside of familiar territory limits creative development, aligning with the findings of Asemsro and Obinnim (2020), who noted that many students struggle to extract key features from their sources of inspiration and apply them effectively in their design work.

Instructors noted that the design variation phase required both sufficient outputs and qualitative depth. However, they reported that students often struggled to engage in meaningful exploration due to psychological pressure stemming from rigid tutorials and tight course schedules. This pressure tended to limit students' willingness to take creative risks or engage in trial-and-error processes. According to instructors, students often remained within familiar boundaries rather than exploring new ideas (P3). Similarly, several instructors observed that time constraints lead students to prioritize completing a required number of variations over deep, thoughtful development (P4). Both reported that students frequently opted for safer, more efficient approaches instead of pursuing innovation. Furthermore, instructors noted that students had difficulty making independent decisions during the design selection process, often becoming overly influenced by instructors' opinions, which could hinder the development of creative autonomy.

Technical design and garment construction challenges

Eight out of 10 instructors reported that the prototype development stage posed significant challenges even for students who performed well in earlier phases of the design process. A major difficulty stemmed from students' limited understanding of garment structure, which often led to design revisions due to issues in pattern making and technical construction.

P10. Students don't really think about things like where the closures should go or where to place the zipper when they're sketching. They only start worrying about those details later on, when they actually start making the garment.

Instructors further reported that time management was a recurring challenge during the prototype phase. When students failed to allocate their time effectively throughout the design process, it often resulted in insufficient time for prototype production. According to Bye (2010), students experience psychological pressure not only from completing their individual tasks but also adhering to scheduled tutorials and class deadlines—factors that can negatively impact their self-concept and learning attitude. Instructors noted that many students devoted a disproportionate amount of time to prototype development, leaving insufficient time for final presentation (P6).

Communication and feedback adaptation issues

Instructors reported that students often struggled to deliver persuasive presentations of their design concepts through public speaking. One instructor observed that some students experienced such intense anxiety about presenting in front of others that the presentation was sometimes conducted in a one-on-one format. Additionally, several instructors noted that students had difficulty interpreting and applying feedback effectively. Rather than viewing critique as an opportunity for growth, these students tended to perceive it as a negative evaluation, often leading to feelings of discouragement (P10). This response was perceived by instructors as leading students to pursue "correct" designs that aligned with instructor expectations, rather than engaging in creative self-expression (P3). Three of the eight instructors teaching in South Korea reported that students often prioritized instructor expectations over original ideas. This may reflect educational norms that emphasize correctness and evaluation, making it harder for students to embrace critique as constructive (Fang & Gopinathan, 2009; Kozato et al., 2023).

P3. With students these days, even though design is supposed to be something they develop on their own from the concept stage, I often see them trying to figure out what the instructor wants and work toward that.

AI tool supported competencies in fashion design

The following themes summarize instructors' perceptions of how AI tools supported students throughout the fashion design process. All instructors specifically reported how AI tools could support students during various stages of the design process. These responses were categorized into the following three subthemes.

Design generation and creative visualization

Seven out of 10 instructors noted that prompt-to-sketch support was particularly useful for students lacking confidence in freehand drawing. Likewise, the prompt-to-image feature of generative AI was reported as a helpful alternative to traditional reference image searches, particularly during the idea development and exploration phases.

P3. With AI tools, students can start by pulling out a bunch of keywords, mix and match them, and get a range of images in return. Then they can look at those images, get inspired, and pick the ones they like to move forward with their design ideas.

Additionally, instructors emphasized the value of realistic image generation, which helped students visualize how garments might appear when worn, including overall silhouette, styling, and mood (P4, P5). This was especially appreciated by students who struggled with illustration, as AI provides a more intuitive and accessible way to conceptualize their designs.

Virtual simulation was also highlighted by instructors as a significant support in this area. It allowed students to visualize their designs and prototypes digitally before physical production. Instructors described its applications in virtual testing during the design review process, final presentations, digital fashion shows, and visual experimentation. One instructor observed that simulating silhouettes and textures without

physical samples enabled iterative refinement and experimentation, which could help streamline the design process and reduce production costs (P3).

Design refinement and visual modification

The most frequently mentioned area of AI tool support among instructors was image refinement. All instructors agreed that tools such as Midjourney, DALL·E, Deep Dream Generator, and Artbreeder—platforms that allowed users to upload and manipulate reference images—were perceived as highly beneficial for generating design variations. However, they emphasized that effective use of these tools depended on students having a clear intention regarding how they wished to modify or evolve the image.

Image merging was also reported as a valuable function in concept development, mood board creation, material and pattern mapping, and style experimentation. According to instructors, merging multiple images through AI could help students generate original styles and explore combinations that do not exist in current design references, thus supporting their imaginative capacity (P1).

Instructors teaching fashion illustration (P2, P4, P9, P10) noted that many students struggled to accurately depict garments when body poses changed, especially when folds or structural shifts occurred. AI tools offering body and pose adjustment were viewed as useful for students with limited anatomical understanding, as they enabled more flexible character development and a wider range of garment expressions.

Design optimization and data-driven decision-making

Instructors reported that AI tools could enhance design efficiency by enabling students to search large datasets using checklist-based inputs, filter results according to design goals, and organize information by attributes such as color or item type. Tools like CST, which operate on a checklist input system, were evaluated by instructors not as generators of new designs, but as tools for identifying and analyzing existing market examples that closely matched a student's intended concept (P3).

Instructors also noted that AI-powered recommendation systems could assist students in structuring their work more effectively, such as automatically generating layout options for presentations or portfolios. They further emphasized that AI could support data-driven decision-making by helping students analyze visual and market information rather than relying solely on intuition (P6).

P8. Students can run their designs through AI, try different versions, and figure out what actually works before they start making anything.

AIED considerations in fashion design

While instructors generally agreed that AI tools could play a supportive role in the fashion design process, they emphasized that the effective integration of AIED into fashion design courses required a strategic approach. The following four key themes emerged from the discussion.

Pedagogical integration of AI

Instructors emphasized that evaluation in a fashion design class should focus less on output quantity and more on students' creative engagement and process when working

with AI tools. They highlighted that reflection, critical thinking, and creative intervention are essential components of learning in design fields (Johnson, 2007), and these should be reflected in how student work is assessed. Rather than counting how many outputs a student submits, instructors advocated for process-oriented, qualitative evaluation that considers how AI tools are used to expand and refine design ideas (P5).

P5. If 20 assignments were allocated before, we used to check if students finished all 20—that was the standard. But now with tools like this, they can generate unlimited results, so the number of outcomes doesn't really mean much anymore.

While embracing AIED, instructors stressed the importance of maintaining the hands-on characteristics of fashion design education (P10). As Grájeda et al. (2024) argued, pedagogical innovation can enhance learning goals while preserving the tactile, practice-based traditions central to the discipline.

P10. In my class, I'm thinking of having students analyze how the AI renders body proportions or distortions in the character and then try sketching them by hand.

They also noted that students should learn to formulate structured prompts and apply field-specific vocabulary when interacting with AI. Given that AI performance depends heavily on user input, instructors perceived that foundational design knowledge and clear conceptual expression were prerequisites. Several instructors suggested that AI-based coursework might be more suitable for advanced students with sufficient background knowledge, rather than beginners. Finally, they discussed hybrid teaching models in which students learn through both AI interaction and human feedback. Instructors agreed that one-on-one critique remained essential in fashion design education but also saw potential in AI's ability to simulate dialogic feedback and act as a co-creator that supported creative thinking and iterative development.

Ethical and learning risks

Ethical concerns were repeatedly raised by instructors, particularly in balancing technological integration with the preservation of core academic values (Heredia-Carroza & Stoica, 2024). Instructors reported concerns that students may submit AI-generated work without modification or reflection, thereby compromising originality and critical thinking. Seven out of 10 instructors warned that excessive dependence on AI may weaken independent reasoning.

P7. We used to tell students to go out and do market research themselves. Now, when you say "research," they just go straight to Pinterest. They need to think for themselves; and while AI tools can be helpful, relying on them too much skips the thinking part. I think students still need that analog trial-and-error experience.

This reflects broader concerns about design fixation, in which overdependence on tools can limit creative diversity and reinforce pre-existing solutions (Crilly & Cardoso, 2017). Instructors emphasized that AI should be positioned not as an answer-generator but as a cognitive support tool.

P5. Sometimes ideas come while you're sketching by hand; there's this back-and-forth between your hand and your mind. But if you're just staring at a screen and typing prompts, I'm not sure how many real ideas will come out. The easier it is to get results, the easier it is for students to stop putting in the effort.

Technical constraints of AI tools

Instructors reported that students may encounter technical limitations when working with AI tools. One concern involved the randomness of AI-generated outputs: while unexpected elements can spark new ideas, they can also undermine student agency. In some cases, the same prompt yielded inconsistent results or generated unintended designs, leading to frustration and increased fatigue during iteration (P5). This reflected previous research suggesting that the capabilities of generative AI were constrained by its training data and may produce inaccurate or irrelevant content (Chatterjee & Dethlefs, 2023).

P5. I kept tweaking the prompt, but the results just weren't what I wanted. It gets tiring, and at some point you think, "Maybe I should just do it myself."

Instructors also highlighted usability issues. While some tools offer easy access, frequent error messages and daily usage limits hinder continuous work. The quality of generated images was also questioned: unrealistic body shapes, awkward poses, or cropped outputs limited their value as fashion-specific references. A recurring critique concerned the lack of structural detail in AI-generated images. Instructors noted that to be applicable in real-world fashion workflows, AI must evolve to provide more precise, construction-oriented outputs.

P9. If AI tools could generate flat pattern outputs like CLO3D, that'd be really helpful. But right now, they just give you images; they don't actually support garment construction.

Institutional and resource barriers

Effective implementation of AIED requires an equitable learning environment that addresses digital disparities among students (Choi et al., 2023). Instructors identified several institutional and structural barriers that hinder the adoption of AI in fashion education. These included limited access due to paid subscriptions, a lack of appropriate courses, insufficient equipment, and a shortage of AI-competent instructors. They reported that many advanced AI tools were subscription-based, making them financially inaccessible to students without institutional support (P1, P9). Instructors emphasized the need for budgetary assistance at the school level to ensure equal access.

Furthermore, instructors pointed out that because AI tools were not integrated into the formal curriculum, both students and faculty lacked systematic opportunities for training and experimentation (P9). In the context of fashion education, where practical skills and exposure to digital tools are essential, theory-based instruction alone was seen as inadequate for building industry-relevant competencies (An & Park, 2021, 2023). In this regard, instructors argued that AIED should not be limited to tool access but must be accompanied by improvements in educational infrastructure and faculty development.

P9. I think tools like Artbreeder could be really useful in illustration classes; but honestly, since I haven't used them myself yet, I'm a bit hesitant to bring them into the classroom.

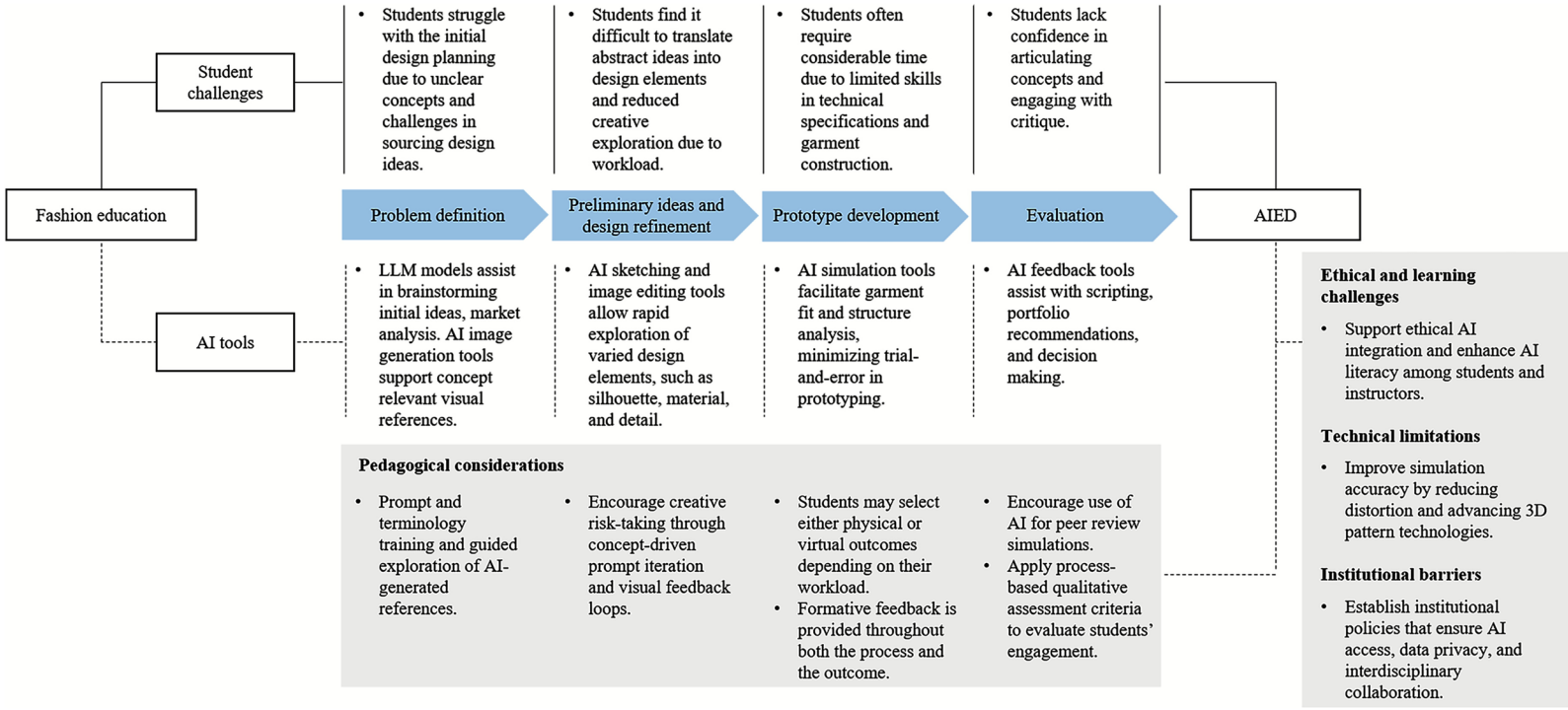


Fig. 3 Framework mapping student challenges and AI tool support across stages of the fashion design process

Discussion

Ouyang and Jiao (2021) emphasized that for AIED to advance meaningfully in educational practice, it must evolve toward AI-empowered learning that supports learner agency and personalized education. They highlighted the need to align the complexity of the learning process with that of AI systems and educational environments. Building on this perspective, Fig. 3 illustrates a stage-based framework that aligns AI tools with student challenges across four phases of the fashion design process—problem definition, ideation and refinement, prototype development, and evaluation—as proposed by LaBat and Sokolowski (1999) and Lamb and Kallal (1992). This framework demonstrates how tools such as large language models, image generators, simulations, and feedback systems can be meaningfully integrated to support student learning, enhance creativity, and promote active engagement. Mapping specific AI capabilities to distinct phases of the design process provides a structured foundation for the pedagogical integration of AIED in fashion education.

Beyond instructional alignment, the framework invites broader reflection on the ethical, technical, institutional, and pedagogical dimensions of AI integration. It facilitates the development of creative thinking and learner-centered engagement and informs preventive strategies to mitigate potential risks, such as the overuse of AI or diminished opportunities for critical reflection. These risks are particularly salient in the context of ethical concerns raised by instructors. For instance, instructors noted that when students uncritically adopt AI-generated outputs, it may hinder the development of core skills typically acquired through trial and error, ultimately reducing originality and creative thinking. Moreover, such practices raise important concerns about fairness and authenticity in student assessment, including the development of appropriate evaluation rubrics that reflect both human effort and AI-supported contributions. These concerns echo earlier findings suggesting that over-reliance on AI may undermine students' critical thinking (Fuchs, 2023). In response, some institutions have opted to restrict or ban the use of AI tools altogether. However, such blanket restrictions may inadvertently intensify attention or dependency on these tools—a dynamic described as the Streisand effect (Jansen & Martin, 2015). Therefore, rather than enforcing prohibitive policies, recent scholarship advocates for a more nuanced approach. This includes reassessing educational goals, refining institutional policies, and developing assessment criteria that strike a balance between leveraging AI's benefits and upholding core educational values such as integrity, fairness, and student agency (Grájeda et al., 2024). In this way, the proposed framework serves as a guide for tool integration as well as a catalyst for rethinking how fashion design education can evolve responsibly in the age of AI.

From a theoretical perspective, the framework extends traditional fashion design process theory by incorporating AI-supported problem-solving. By systematically connecting student challenges with AI functions, it contributes to the development of AI-integrated instructional theory. From an instructional design perspective, the framework provides a practical reference for integrating AI into fashion education. The alignment between student needs and AI capabilities informs curriculum planning, feedback mechanisms, and assessment strategies.

In the problem definition stage, students often struggle with vague concepts and finding design sources. Large language models and image generation tools assist in

brainstorming initial ideas, market exploration, and concept visualization by offering relevant visual references. To maximize effectiveness, prior training in prompt and terminology use is essential. In the ideation and design refinement stage, students may find it difficult to translate abstract ideas into concrete design elements and often experience reduced exploration due to workload. AI sketching and image editing tools allow for visual exploration of varied design elements, including silhouette, material, and detail. However, overreliance and random outputs may compromise originality. Instructor guidance is key to encouraging creative risk-taking and ownership through feedback loops and concept-driven ideation. Instructor guidance that encourages critical thinking and creative ownership is therefore essential. In the prototype development stage, students often experience challenges due to limited skills in technical specifications and garment construction, as well as restricted time. AI simulation tools facilitate garment fit and structural analysis, minimizing trial-and-error in prototyping. Providing flexibility based on workload, these tools allow students to select between physical or virtual outcomes with iterative feedback on both process and result. However, due to the practical nature of this phase, AI tools cannot fully substitute for hands-on learning. Foundational knowledge in patternmaking and garment structure remains essential. Wu et al. (2021) emphasize that human–AI collaboration should be based on task characteristics—human-led for creative and strategic decisions, and AI-assisted for repetitive, optimization-oriented tasks. Enhancing AI tools with precise 3D simulation and integration with platforms like CLO3D is necessary for future applicability in garment production. In the presentation phase, AI-assisted script writing and rehearsal tools can reduce anxiety and improve delivery. AI feedback systems also promote self-assessment and reflection. By adopting process-based qualitative assessment rather than outcome-focused evaluation, educators can better cultivate creativity, self-direction, and problem-solving skills.

Conclusions

This study explored how AI tools can support students in the fashion design process by identifying key considerations for integrating AIED into fashion education. Through in-depth interviews with instructors, the research revealed four major areas of student challenge—initial planning, ideation, technical construction, and communication—as well as three core competencies supported by AI tools: design generation, refinement, and optimization. These findings were synthesized into a structured framework that aligned common student difficulties with the potential affordances of AI technologies, offering a foundation for curriculum design and instructional strategies in AI-integrated fashion education.

The study highlighted that while AI tools could enhance ideation, visualization, and decision-making, their educational value depended on intentional integration. AIED must go beyond tool adoption to include prompt literacy, domain knowledge, and reflective thinking. Moreover, the role of instructors remains critical not only in guiding tool use but also in fostering critical, creative, and ethical engagement with AI. Practical barriers such as limited access to paid tools, lack of technical training, and institutional infrastructure gaps must also be addressed to ensure equitable and sustainable implementation. Pedagogically, shifting toward process-based assessment

and hybrid feedback models that balance human and AI input are essential for cultivating student agency and design autonomy.

Moving toward AI-empowered learning, fashion design education must strike a balance between tradition and innovation, preserving hands-on, tactile learning while embracing the creative potential of AI. Future research should continue examining how specific AI tools can be adapted to different levels of learner expertise and how collaborative AI-human workflows can enhance both educational and professional design practices.

This study contributes to the field by moving beyond the technical applications emphasized in previous research, instead examining how AI integration can reshape pedagogical paradigms in fashion design education. Specifically, it enhances the connection between curriculum and technology by mapping the concrete contributions of AI across design process stages. Drawing on thematic analysis and insights from 10 instructors, the study proposed a conceptual framework that classifies AI-supported functions. The research also identified educational opportunities and challenges associated with AI use, emphasizing the need to revise traditional assessment criteria and pursue intentional integration of AI tools into the learning process. Practically, it provided actionable guidelines for educators to incorporate AI into teaching practices by illustrating how AI tools could address specific student challenges throughout the design process. Additionally, the study underscored the necessity of institutional support, such as solving access issues, embedding AI into the formal curriculum, and building instructor competency, to ensure the successful implementation of AIED. Finally, the study confirmed the importance of clearly delineating the roles of AI and human designers in the learning environment. Although AI serves as a powerful assistive tool, creative decision-making should remain the responsibility of students.

While this study offered important insights for developing AIED strategies in fashion design education, its findings should be interpreted with caution due to the exploratory nature of the research and its limited sample size. Broader generalization requires further investigation across diverse cultural and institutional contexts through quantitative approaches. Future research should examine how AI tools affect students' actual learning experiences from the learners' perspectives more closely. Moreover, although this study provided an overview of various roles that AI tools can play in fashion design education, it did not offer an in-depth analysis of the functions and limitations of specific tools. Subsequent studies should focus on empirically evaluating the effectiveness of AI tools tailored to fashion design through classroom-based applications.

Abbreviations

AIED	Artificial Intelligence in Education
AI	Artificial Intelligence
CST	Creativity Support Tool

Supplementary Information

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Supplementary Material 1.

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Author contributions
HA originated the research idea. HA carried out the research and drafted the first manuscript. MP helped with interpretation and improvement of the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Institutional Review Board of Pai Chai University (IRB No. 2-1040766-AB-N-01-R-2024-02). All participants provided informed consent prior to their participation in the study.

Competing interests
Hyosun An and Minjung Park are Editorial Board Members of Fashion and Textiles. Editorial Board Member status has no bearing on editorial consideration.

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