Stitching the Future: Exploring the Role of Augmented Reality in Revolutionizing Fashion Design

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ABSTRACT

Augmented Reality (AR) has the potential to transform fashion design education by enhancing creativity, engagement, and skill development. This study explores the integration of AR in garment design education, focusing on students' awareness, challenges in adoption, and its impact on learning experiences. Using a mixed-methods approach, the research examines how AR fosters innovation and bridges the gap between theoretical knowledge and practical application.

The findings reveal that students have limited familiarity with AR technology, and its adoption is hindered by challenges such as technological adaptation struggles, resource accessibility barriers, training and support deficiencies, and cultural resistance to innovation. Despite these barriers, AR demonstrates a significant ability to improve creativity and technical skills by enabling students to visualize designs, experiment with virtual prototypes, and refine ideas in interactive and immersive environments. AR also increases engagement and motivation, encouraging students to explore innovative design possibilities while reducing material waste and streamlining the design process.

This study highlights the need for institutions to support AR integration through awareness campaigns, affordable tools, and comprehensive training programs. By addressing these challenges, AR can modernize fashion design education and equip students with the skills needed to succeed in a rapidly evolving industry. Future research should explore its long-term impact, scalability across creative disciplines, and potential for integration with emerging technologies like Virtual Reality and Artificial Intelligence. AR offers a promising pathway to prepare students for the demands of the global fashion industry, fostering creativity, adaptability, and innovation.

Keywords: Augmented Reality, Fashion Design, Immersive Learning, Technological Innovation, Skill Development

INTRODUCTION

Fashion design education plays a crucial role in equipping students with the creativity, innovation, and technical skills necessary to thrive in a competitive and rapidly evolving industry. As the fashion world continues to change, the integration of technology has become increasingly vital in enhancing the learning process. Traditional teaching methods in fashion design, which often rely on hands-on activities and theoretical instruction, face several challenges [17]. These include limited opportunities for engagement, difficulties in visualizing complex garment designs, and a disconnect between theoretical knowledge and practical application. Moreover, traditional learning approaches, such as reading text-heavy materials with minimal visual aids, often fail to capture students' interest and can discourage them from fully engaging with the material [5]. This highlights the need for innovative educational solutions that make learning more effective and appealing [8], [16].

The 21st century has witnessed significant technological advancements that have reshaped the educational landscape, offering opportunities for immersive and interactive learning experiences [12]. Research has shown

that technology-embedded education fosters innovative teaching practices, enhances student motivation, and improves the effectiveness of learning in real-world contexts [33]. Among these emerging technologies, Augmented Reality (AR) has gained significant attention for its potential to transform education. AR overlays digital elements onto the physical world, creating interactive and immersive experiences that enhance traditional learning methods. Studies have highlighted the pedagogical value of AR, demonstrating its ability to improve content understanding, motivation, interaction, and collaboration among students [14]. In fields such as Natural Sciences and Mathematics, AR has shown medium to high effectiveness in improving learning outcomes compared to traditional methods like lectures or multimedia resources [23].

The transformative potential of AR lies in its ability to create immersive digital environments that foster creativity, critical thinking, and problem-solving skills. Huang et al. [9] emphasized that AR is reshaping teaching methods, student behavior, and creativity by enabling learners to visualize abstract concepts and engage in dynamic, interactive learning experiences. AR serves as a catalyst for creativity, helping students explore and experiment in ways that traditional pedagogical approaches cannot achieve [9].

While AR has been widely applied in STEM education, its application in Technical-Vocational Education, particularly in Garments and Fashion Design Technology, remains underexplored. Fashion design is a field that relies heavily on creativity, visualization, and experimentation, making it an ideal candidate for AR integration [7]. However, traditional fashion design education often involves manual processes, such as pattern making, fabric handling, and physical prototyping, which can be time-consuming, resource-intensive, and limiting in terms of experimentation. The integration of AR into fashion design education could address these challenges by enabling virtual prototyping, fabric simulation, and interactive design visualization [4]. AR has the potential to enhance the creative process, reduce material waste, and streamline garment production, offering students a more engaging and efficient way to learn [4], [10].

Despite its benefits, the adoption of AR in fashion design education is still in its infancy. Many students and educators remain unaware of the potential applications of AR in this field. Limited exposure to AR technologies in fashion design programs has resulted in a lack of familiarity and practical experience [27]. Additionally, several barriers hinder the widespread use of AR in education, including financial constraints, the high cost of AR tools, the steep learning curve associated with the technology, and insufficient institutional support [21],[25]. These challenges underscore the need for targeted training programs, financial investment, and institutional readiness to fully harness the potential of AR in fashion design education.

This study seeks to address the gaps in awareness and application of AR in fashion design education by exploring its impact on creativity, learning experiences, and skill development among Garments and Fashion Design Technology students at Mariano Marcos State University, College of Teacher Education. Specifically, it examines students' awareness of AR, the challenges involved in its integration, and how AR can enhance creativity and skill development compared to traditional methods. By investigating these aspects, the study contributes to the growing body of knowledge on AR's transformative potential in technical-vocational education and provides insights into strategies for its effective implementation.

As emerging digital technologies continue to shape various industries, integrating AR into fashion design education may open new opportunities for interactive learning, creativity, and skill development. By modernizing fashion design education, AR has the potential to prepare students to meet the demands of a rapidly evolving industry, ensuring they are equipped with the skills and knowledge necessary to succeed in the future workplace.

Theoretical Frameworks

This study was grounded in six key learning theories to guide the exploration and evaluation of Augmented Reality (AR) in fashion design education for garment students, as shown in Figure 1. These theories include Constructivist Learning Theory, Kolb's Experiential Learning Theory, Cognitive Load Theory, Technology Acceptance Model (TAM), Situated Learning Theory, and Diffusion of Innovations Theory. Together, these frameworks provided a foundation for understanding how AR influences students' creativity, skill development,

awareness, and the challenges of adopting this technology in education. They also shaped the study's methods and analysis.

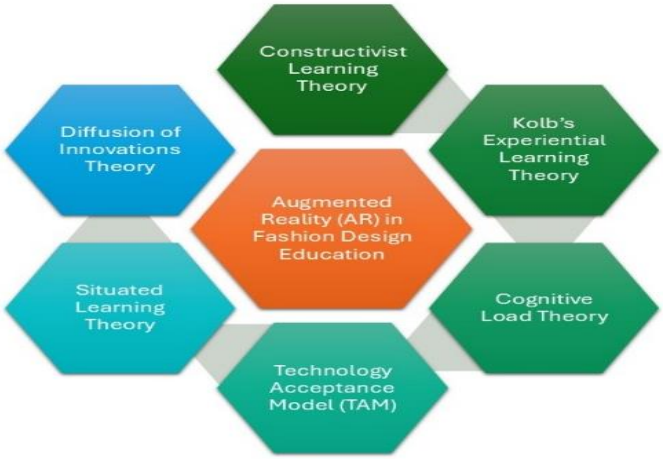

Figure 1. Theoretical Paradigm of the Study.

Constructivist Learning Theory, developed by Jean Piaget (1960) and Lev Vygotsky (1978), highlights that students build knowledge by connecting new information to their prior experiences. In the context of AR, students interacted with virtual garment prototypes, allowing them to experiment creatively and link new concepts to what they already knew. This theory supported the design of AR tools that encourage active learning, scaffolded activities, and opportunities for students to visualize and manipulate designs.

Kolb's Experiential Learning Theory (1984) emphasizes learning through hands-on experiences, involving four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. AR allowed students to engage in immersive, practical tasks like virtual garment creation, reflection, and testing of ideas. This hands-on approach aligned with experiential learning principles, enhancing creativity and helping students apply theoretical knowledge to real-world tasks.

Cognitive Load Theory, introduced by John Sweller (1988), focuses on reducing unnecessary mental effort during learning. AR simplified complex garment design processes by visualizing steps and breaking them into manageable parts, helping students focus on key concepts and creative tasks. This theory guided the development of AR tools to optimize learning efficiency and cognitive engagement.

The Technology Acceptance Model (TAM), developed by Fred Davis (1989), explains how users adopt new technologies based on their perceived usefulness and ease of use. This framework was used to analyze students' awareness of AR and identify barriers to its adoption, such as technical difficulties or lack of training. By understanding these factors, the study proposed strategies to improve AR integration in fashion design education.

Situated Learning Theory, proposed by Jean Lave and Etienne Wenger (1991), emphasizes learning in real-world contexts. AR provided students with virtual environments that simulated realistic garment design processes, allowing them to practice and refine their skills in authentic settings. This theory helped explain how AR bridged the gap between theoretical learning and practical application.

Diffusion of Innovations Theory, developed by Everett Rogers (1962), describes how new technologies are adopted and spread within communities. This theory was used to explore how AR awareness spread among students and the factors that influenced its adoption, such as compatibility with existing methods and accessibility. It also informed strategies for encouraging AR adoption in education.

By integrating these six theories, the study provided a strong framework for understanding the impact of AR on students' learning, creativity, and skill development, as well as the challenges of adopting this technology in fashion design education. These theories guided the study's approach and offered insights into how AR can transform learning experiences.

RESEARCH METHODS

Research Design

This study employed a mixed-methods research design to examine the role of Augmented Reality (AR) in fashion design education among Garments and Fashion Design Technology students at Mariano Marcos State University. Quantitative data were collected through surveys to assess students' awareness of AR, which were analyzed using descriptive statistics. Pre- and post-intervention tests and observational checklists were used to evaluate AR's impact on learning experiences, analyzed using paired t-tests.

Qualitative data were gathered through semi-structured interviews with students and instructors to identify challenges in integrating AR, which were analyzed using thematic analysis. A comparative analysis of student outputs (traditional vs. AR-based designs) and student portfolios was conducted to assess the impact of AR on creativity and skill development.

Participants included students and instructors, with data analyzed using statistical methods and thematic analysis to provide insights into AR's effectiveness in enhancing education and creativity in fashion design.

Locale of the Study

The study was conducted at Mariano Marcos State University, specifically within the College of Teacher Education (CTE), recognized as a Center of Teaching Excellence. Within CTE, the Technical-Vocational Livelihood Education Department serves as the primary setting for the study. This department offers two programs: Bachelor of Technical-Vocational Teacher Education (BTVTEd) and Bachelor of Technology and Livelihood Education (BTLEd), which provide students with eight specializations, including Garments and Fashion Design Technology, creating a diverse and specialized learning environment.

The BTLEd program is Level 4 accredited, underscoring its commitment to academic excellence, a rigorous curriculum, and advanced facilities. This accreditation reflects the program's ability to produce highly skilled graduates who are prepared to meet the demands of technical-vocational education. The presence of specialized tracks, such as Garments and Fashion Design Technology, makes the department an ideal setting for this study, as it offers access to students and instructors who are actively involved in fashion design education. Furthermore, the university's emphasis on innovation and technology aligns seamlessly with the integration of Augmented Reality into the curriculum, making it a highly suitable locale for examining its impact on education and creativity.

Population and Sampling Procedures

The population of the study consisted of students and instructors from the Technical-Vocational Livelihood Education Department of Mariano Marcos State University, specifically those involved in the Garments and Fashion Design Technology and Home Economics specializations. The students were enrolled in the Bachelor of Technical-Vocational Teacher Education (BTVTEd) program, specializing in Garments and Fashion Design Technology, and the Bachelor of Technology and Livelihood Education (BTLEd) program, specializing in Home Economics. These students were 3rd-year students enrolled in the second semester of the academic year 2024–2025, ensuring that the participants were sufficiently advanced in their programs and had relevant exposure to technical-vocational education and their respective specializations.

The sampling procedure utilized a total enumeration method, wherein all members of the identified population were included as participants in the study. This approach ensured that every 3rd-year student enrolled in the BTVTEd program taking Garments and Fashion Design Technology and the BTLEd program taking Home Economics, as well as their instructors, were part of the study. By including the entire population, the study was able to gather comprehensive data and insights from all relevant individuals, providing a more accurate and holistic understanding of the impact of integrating Augmented Reality into the curriculum.

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Research Instrument

The study utilized a combination of researcher-made survey questionnaires, semi-structured interview guides, observational checklists, and portfolio analysis as primary tools for data collection. These instruments were developed based on an extensive review of related literature and were carefully aligned with the research questions to ensure their relevance and effectiveness in addressing the objectives of the study.

The survey questionnaire was designed to gather quantitative data on the level of awareness of Garments students regarding Augmented Reality in fashion design education. It employed a 4-point Likert scale to measure respondents' awareness, with interpretations ranging from Highly Aware (4) to Not Aware (1). The questionnaire was structured to include demographic information such as age, gender, and specialization, ensuring a comprehensive understanding of the respondents' profiles. Mean scores were calculated to evaluate the overall level of awareness among the participants.

To explore the challenges involved in integrating Augmented Reality into fashion design education, a semi-structured interview guide was utilized. This qualitative instrument was designed to elicit detailed responses from both students and instructors, focusing on their experiences, perceptions, and the barriers they encountered during the integration process. The open-ended format allowed participants to provide unique insights, enriching the study's findings.

For the comparative analysis of student outputs, the study employed a portfolio review method alongside Pre- and Post-Intervention Assessment and Observation to evaluate designs created using traditional methods and those created with Augmented Reality tools. A validated rubric was used to assess the portfolios based on the following criteria: Innovation in Design, Detail and Accuracy, Complexity of Designs, Visualization, Time Efficiency, Engagement and Motivation, and Portfolio Quality. The inclusion of Pre- and Post-Intervention Assessment provided a structured comparison of student performance before and after the integration of AR tools, while Observation allowed for real-time insights into students' engagement and creative processes. This multi-faceted approach enabled the researchers to thoroughly evaluate the impact of Augmented Reality on students' creativity, engagement, and design quality.

To assess how Augmented Reality enhances students' development in terms of learning experience and skill development, the study utilized Pre- and Post-Intervention Tests, Survey Questionnaires, and Interviews. The pre- and post-intervention tests measured changes in students' knowledge and skills before and after the integration of Augmented Reality into the curriculum. The survey questionnaires gathered insights into students' perceptions and experiences, while the interviews provided in-depth qualitative data from both students and instructors. Additionally, student portfolios were analyzed to track progress in their technical and creative skills over time. This combination of methods provided a comprehensive understanding of how Augmented Reality impacts students' learning and skill development.

To ensure the validity and reliability of the instruments, content validation was conducted by a panel of experts, including educators, research specialists, and technical-vocational education practitioners. A pilot test was also carried out with a group of participants who were not included in the actual study sample, resulting in a high reliability score. The finalized instruments were made available in both printed and digital formats to ensure accessibility for all respondents. This multi-method approach provided a comprehensive and triangulated dataset that effectively addressed the research objectives.

Data Gathering Procedures

The researchers employed a systematic approach to collect data for the study. A formal request letter was addressed to the Dean and Department Chair of the college to seek approval for the conduct of the study among the target population, which included third-year students enrolled in the Bachelor of Technical-Vocational Teacher Education (BTVTEd) and Bachelor of Technology and Livelihood Education (BTLEd) programs, as well as their instructors. Once approval was granted, the researchers coordinated with the respective instructors to schedule data collection activities and ensure the convenience of the participants.

The survey questionnaire was distributed using face-to-face methods in printed copies only. The questionnaires were handed out to students during their vacant hours or institutional activities, ensuring that participants had sufficient time to complete them. A cover letter was attached to each questionnaire, explaining the purpose of the study, the voluntary nature of participation, and the assurance of confidentiality and anonymity of their responses. The researchers provided assistance in case of any clarifications and ensured that the questionnaires were collected promptly after completion to avoid delays.

To achieve the study's goal of assessing the effectiveness of Augmented Reality (AR) in fashion design education, selected hands-on learning topics were incorporated into the curriculum using AR tools. These topics were carefully chosen to align with the objectives of the study and were designed to allow students to directly interact with AR technology in garment design processes. During the intervention period, students engaged in practical activities that involved creating designs and exploring garment construction techniques using AR applications. These experiences were documented to provide additional qualitative data on the impact of AR integration.

Semi-structured interviews were conducted with selected participants to gather qualitative data. These interviews were scheduled in advance and conducted face-to-face in a comfortable and non-intrusive environment, allowing participants to freely share their experiences and insights regarding the integration of Augmented Reality in fashion design education.

For the comparative analysis of student outputs, the researchers collected portfolios and project outputs from students who worked on garment designs using both traditional methods and Augmented Reality tools. All students were exposed to both approaches, ensuring an inclusive use of all methods to allow for a balanced comparison of their technical and creative competencies. A validated rubric was employed to evaluate the portfolios based on the following criteria: Innovation in Design, Detail and Accuracy, Complexity of Designs, Visualization, Time Efficiency, Engagement and Motivation, and Portfolio Quality. Observational checklists were used during the intervention period to document students' learning experiences and interactions with AR technology, providing qualitative insights into their engagement and creative processes. Pre- and post-intervention evaluations were conducted to measure changes in students' technical and creative skills, while the portfolio analysis focused on assessing their progress in applying these skills effectively in garment design. This comprehensive data gathering approach ensured a robust evaluation of the impact of Augmented Reality on students' skill development in garment design.

The data collection period lasted for three months to ensure sufficient time for all participants to contribute to the study. Regular follow-ups were conducted through announcements during institutional activities and reminders through instructors to encourage participation and ensure a high response rate. All printed responses and other collected data were manually encoded into a spreadsheet for organization and statistical analysis. This systematic procedure ensured the accuracy, reliability, and comprehensiveness of the data gathered for the study.

Statistical Treatment

The data collected for the study underwent a systematic process to ensure accuracy, reliability, and meaningful analysis. Data cleansing was performed to remove incomplete responses and invalid entries, ensuring a clean dataset for statistical treatment. Microsoft Excel was used for initial data organization, while advanced statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS).

For Research Question 1, which focused on the level of awareness of garment students about Augmented Reality in fashion design, descriptive statistics such mean score were utilized to analyze the responses from the survey questionnaires. These statistical methods provided a clear overview of students' awareness levels and patterns in their responses.

To address Research Question 2, which explored the challenges of using Augmented Reality in fashion design education, qualitative data gathered from interviews and focus group discussions were subjected to thematic analysis, following the six-phase framework by Braun and Clarke (2006). This systematic approach involved familiarizing with the data, generating initial codes, searching for themes, reviewing themes, defining and

naming themes, and producing the final report. Through this process, the researchers were able to identify recurring themes, barriers, and insights shared by students and instructors regarding the integration of Augmented Reality tools into the curriculum. Braun and Clarke's method ensured a rigorous and structured analysis, allowing for a comprehensive understanding of the challenges faced during the adoption of AR in fashion design education.

For Research Question 3, which examined how Augmented Reality improves creativity in garment design compared to traditional methods, a comparative statistical approach was employed. Pre- and post-intervention assessments were analyzed using paired t-tests to determine significant differences in creativity and design quality before and after the integration of Augmented Reality tools. Student outputs were evaluated through a portfolio review method, utilizing a validated rubric with specific criteria: Innovation in Design, Detail and Accuracy, Complexity of Designs, Visualization, Time Efficiency, Engagement and Motivation, and Portfolio Quality. Average scores for each criterion were calculated for both traditional methods and AR-based methods, providing quantitative evidence of AR's impact on creativity. Observations documented during the intervention period further enriched the analysis by offering qualitative insights into students' creative processes and engagement.

For Research Question 4, which focused on how Augmented Reality enhances students' learning experience and skill development, both quantitative and qualitative methods were applied. Pre- and post-intervention tests were analyzed using paired t-tests to measure significant changes in students' knowledge, and skills after engaging in AR-based activities. Survey questionnaires provided additional quantitative data on students' perceptions of their learning experiences, while interviews offered qualitative insights from both students and instructors. Furthermore, student portfolios were analyzed to track progress in technical and creative skills over time, providing evidence of skill development facilitated by Augmented Reality tools.

The systematic application of descriptive statistics, thematic analysis, paired t-tests, and portfolio review ensured the reliability and comprehensiveness of the findings. These statistical treatments allowed the researchers to effectively address each research objective and provide meaningful insights into the integration of Augmented Reality in fashion design education.

Ethical Consideration

The study adhered to strict ethical guidelines to ensure the protection of participants' rights and the integrity of the research process. Prior to the commencement of data collection, the researchers obtained formal approval from the Dean of the College of Teacher Education at Mariano Marcos State University. Informed consent was sought from all participants, including Garments and Fashion Design Technology students and instructors, through a cover letter attached to the survey questionnaires and interview invitations. The cover letter clearly outlined the purpose of the study, the voluntary nature of participation, and the assurance of confidentiality and anonymity of their responses.

Participants were assured that their personal information and responses would be kept strictly confidential and used solely for academic purposes. To safeguard anonymity, all survey and interview data were coded, and no identifying information was included in the final analysis or reporting. The researchers also ensured that participation in the study was voluntary, and participants had the right to withdraw at any stage without any repercussions.

During the semi-structured interviews, participants were provided with a comfortable and non-intrusive environment to freely share their insights. The researchers maintained a neutral stance and avoided any form of coercion or leading questions to ensure the authenticity of the responses. Audio recordings of the interviews were conducted only after obtaining explicit permission from the participants, and these recordings were securely stored and destroyed after transcription and analysis.

The intervention activities involving Augmented Reality tools were carefully planned to align with the curriculum and did not disrupt regular classes or impose additional burdens on students or instructors.

Observational checklists and pre- and post-intervention tests were administered in a manner that respected participants' schedules and minimized inconvenience.

Additionally, the researchers ensured that the comparative analysis of student outputs and portfolios was conducted objectively, with clear criteria for evaluation. Feedback from instructors was sought to validate the assessments and ensure fairness.

To maintain the integrity of the study, all research instruments underwent content validation by a panel of experts, and a pilot test was conducted to ensure reliability. The researchers also complied with institutional policies and ethical standards set by Mariano Marcos State University, ensuring that the study adhered to established guidelines for academic research.

Overall, the study prioritized the rights, privacy, and well-being of all participants while maintaining transparency and objectivity throughout the research process.

RESULTS AND DISCUSSIONS

Level of Awareness of Augmented Reality in Fashion Design

Table I presents the level of awareness of garment design students regarding Augmented Reality (AR) in fashion design education, with an overall mean score of 2.32, interpreted as "Unaware." The findings highlight that students have limited familiarity with AR applications and their potential to enhance garment design processes, indicating a significant gap in knowledge concerning the integration of AR into fashion design education.

Table I Level Of Awareness Of Garments Students Regarding Augmented Reality In Fashion Design Education

Statement	Mean	DI
1. I am aware of Augmented Reality applications in fashion design education.	2.2	Unaware
2. I understand that Augmented Reality combines real and virtual environments to enhance garment design and visualization.	2.4	Unaware
3. I am aware that Augmented Reality is interactive and can be used to improve fashion design processes.	2.3	Unaware
4. I understand that Augmented Reality operates in three dimensions, which is useful for visualizing garments and designs.	2.1	Unaware
5. I am familiar with Augmented Reality applications like virtual fitting rooms and garment prototyping in fashion design.	2.35	Unaware
6. I am aware that Augmented Reality can engage and encourage fashion design students by providing immersive learning experiences.	2.45	Unaware
7. I understand that Augmented Reality applications can motivate fashion design students by enhancing creativity and interaction.	2.5	Aware
8. I am aware that Augmented Reality applications can be used on devices like computers, smartphones, and tablets for fashion design purposes.	2.55	Aware
9. I am aware that Augmented Reality applications can help garment students improve their skills, creativity, and design processes.	2.25	Unaware

10. I understand that Augmented Reality enables fashion designers to experiment with virtual prototypes and test designs efficiently.	2.15	Unaware
Overall Mean Score	**2.32**	**Unaware**

Note: DI-Descriptive Interpretation; 3.25 - 4.00 Very Aware (VA); 2.49 – 3.24 Aware (A); 1.75 -2.48 Unaware (U); 1.00 – 1.74 Very Unaware (VU)

Students scored 2.2 on their awareness of AR applications in fashion design education, demonstrating that they are largely unaware of how AR can be applied in their coursework. Similarly, their understanding of AR's ability to combine real and virtual environments to enhance garment design and visualization (M=2.4) remains low, suggesting limited exposure to the fundamental principles of AR technology. Research has emphasized the transformative potential of AR in design education, particularly in bridging physical and virtual spaces to improve creativity and efficiency [2], [4].

The findings further reveal that students lack awareness of AR's interactive nature and its ability to improve fashion design processes (M=2.3), as well as its three-dimensional functionality for visualizing garments and designs (M=2.1). These results align with studies by Kamińska et al. [13], which emphasize the importance of educating students on AR's technical aspects to maximize its utility in design-related fields. Additionally, students scored 2.35 on their familiarity with specific AR applications, such as virtual fitting rooms and garment prototyping, highlighting the need for exposure to practical tools that are increasingly utilized in the fashion industry [10], [28].

While students demonstrated limited awareness of AR's ability to provide immersive learning experiences (M=2.45), they showed moderate awareness of its potential to enhance creativity and interaction among fashion design students (M=2.5). This indicates that students recognize AR's motivational and creative benefits but lack a deeper understanding of its practical applications. Studies have shown that AR fosters creativity and engagement, particularly when integrated into hands-on learning environments [9], [24].

Moreover, students rated their awareness of AR's compatibility with devices such as computers, smartphones, and tablets at 2.55, interpreted as "Aware." This suggests that students acknowledge the accessibility of AR technology across various platforms, consistent with findings by Koumpouros [14] and Wei et al. [33], which highlight the importance of device compatibility in promoting AR adoption in education. However, their awareness of AR's ability to improve skills, creativity, and design processes (M=2.25) and its use in experimenting with virtual prototypes and testing designs efficiently (M=2.15) remains low, reflecting the need for practical demonstrations of AR's potential in technical skill development [25], [21].

In conclusion, the results indicate that garment design students have minimal awareness of AR technologies in fashion design education. Although aspects such as creativity and device compatibility are moderately recognized, most students lack comprehensive knowledge about AR tools and their benefits in enhancing learning and design processes. These findings are consistent with existing literature, which emphasizes the need for targeted educational interventions to bridge the awareness gap and unlock AR's full potential in fashion design education [10], [13], [28].

Challenges in Integrating Augmented Reality in Fashion Design Education

Table II highlights the challenges encountered during the integration of Augmented Reality (AR) in laboratory activities within fashion design educational settings. The challenges are categorized into four main themes: Difficulty in Adapting to New Technology, Limited Access to AR Tools and Resources, Insufficient Training and Support, and Resistance to Shifting from Traditional Methods.

Table Ii Challenges In Integrating Augmented Reality In Fashion Design Education

Challenges	**Codes**	***F***	***%***	**Rank**
Technological Adaptation Struggles	Steep learning curve for AR tools	8	80%	1
	Lack of familiarity with AR interfaces	5	50%	2
	Difficulty in connecting AR to learning outcomes	3	30%	3
Resource Accessibility Barriers	High cost of AR hardware and software	7	70%	1
	Limited institutional investment	5	50%	2
	Insufficient availability of AR tools	4	40%	3
Training and Support Deficiencies	Lack of professional development programs	6	60%	1
	Absence of technical workshops	4	40%	2
	Limited guidance during AR integration	3	30%	3
Cultural Resistance to Innovation	Preference for traditional teaching methods	3	30%	1
	Concerns about AR's effectiveness	2	20%	2
	Hesitation to adopt innovative technologies	1	10%	3

Each theme is broken down into specific issues (codes), ranked by frequency and percentage to provide a clear understanding of the barriers faced.

The most prominent challenge identified in this study falls under Technological Adaptation Struggles. Among the respondents, 80% reported the steep learning curve for AR tools as a significant issue, highlighting how both students and educators face difficulties with the technical aspects of AR. One teacher explained, *"It took me weeks to understand how to use the AR software effectively. I felt overwhelmed at first, especially since I had no prior experience with such advanced tools."* Similarly, a student shared, *"The interface was so complicated that I spent more time figuring out how to use the tool than actually focusing on the learning task."* Additionally, 50% of respondents noted a lack of familiarity with AR interfaces, while 30% pointed to the difficulty of connecting AR experiences to learning outcomes. As one teacher remarked, *"Sometimes it felt like we were using AR just for the sake of technology, and it was hard to ensure the activities were tied to the learning objectives."* These findings align with Kamińska et al. [13], who emphasized the importance of user-friendly AR tools and better instructional design to bridge the gap between technology and educational goals. Similarly, Liono et al. [16] highlighted that AR's effectiveness depends on its ease of use, as overly complex interfaces often hinder learning rather than enhance it.

Resource Accessibility Barriers also emerged as a critical challenge, with 70% of respondents citing the high cost of AR hardware and software as a major obstacle. Financial constraints make it difficult for institutions to adopt AR technologies, which is further compounded by limited institutional investment (50%) and insufficient availability of AR tools (40%). One teacher noted, *"The school couldn't afford to purchase enough AR devices for all students, so we had to share, which slowed down the entire process."* A student similarly expressed frustration, saying, *"I wanted to practice using AR at home, but the software was too expensive for me to afford on my own."* These findings are consistent with Borisova et al. [4], who noted that the financial burden of AR

adoption often hinders its widespread use in education. Similarly, Koumpouros [14] emphasized that the high cost of AR devices and software remains one of the most significant barriers to their integration in educational institutions. To address these challenges, institutions must allocate resources strategically to ensure accessibility and affordability, thereby facilitating the adoption of AR in laboratory activities. As Silvestri [28] pointed out, strategic investments in digital tools can help bridge the gap between resource constraints and the growing demand for innovative teaching methods.

Another key challenge relates to Training and Support Deficiencies. A lack of professional development programs was reported by 60% of respondents, underscoring the need for comprehensive training to equip educators and students with the skills required to effectively use AR. One teacher stated, *"I was expected to use AR in my lessons, but there was no formal training provided. I had to figure it out on my own, which was frustrating and time-consuming."* Furthermore, 40% of respondents noted the absence of technical workshops, while 30% pointed to limited guidance during AR integration. One student explained, *"We were given the tools but not enough instruction on how to use them effectively. It felt like we were thrown into the deep end without a life jacket."* These findings align with Huang and Musah [9], who stressed the importance of hands-on training and ongoing support to overcome these barriers. Similarly, Perifanou et al. [23] emphasized that professional development programs must be tailored to address educators' specific needs, ensuring they feel confident and competent when using AR tools in their teaching. Mohamed and Sicklinger [18] also advocated for the inclusion of structured workshops and technical support during AR adoption to minimize frustration and enhance user confidence.

Finally, Cultural Resistance to Innovation was also identified as a significant barrier. Thirty percent of respondents expressed a preference for traditional teaching methods, reflecting hesitation to embrace innovative technologies like AR. One student commented, *"I prefer using physical materials like paper and fabric for my designs. AR feels too artificial and disconnected from the real-world process."* Concerns about AR's effectiveness (20%) and reluctance to adopt new technologies (10%) further highlight the need for awareness campaigns and evidence-based demonstrations of AR's potential to enhance learning outcomes. A teacher shared, *"I've been teaching the same way for years, and it works. I don't see why we need to change everything just because there's a new technology available."* These findings align with Risdianto et al. [24], who emphasized the importance of showcasing AR's benefits to overcome skepticism and foster a culture of innovation among educators and students. Similarly, Thangavel et al. [30] noted that cultural resistance often stems from a lack of understanding of how AR can complement traditional teaching methods, highlighting the need for awareness campaigns and pilot programs to demonstrate its value.

Despite these challenges, the study also highlights AR's potential to transform learning by fostering creativity, engagement, and skill acquisition. For example, one student shared, *"Once I got the hang of it, I was able to create designs that I never thought were possible before. It made me feel more confident in my abilities."* Another teacher noted, *"The students were much more engaged during AR activities compared to traditional lectures. They were excited to explore and interact with the content."* These findings align with Jalil [10], who emphasized that AR not only enhances creativity but also provides students with the confidence to experiment and innovate in their designs. By addressing the barriers identified—through investments in affordable AR tools, user-friendly applications, comprehensive training programs, and cultural shifts toward innovation—educators and students can unlock AR's full potential. This will not only enhance creativity and engagement but also foster deeper learning experiences in laboratory settings.

In summary, these findings reveal that the integration of AR in laboratory activities is hindered by technical, financial, and attitudinal barriers. To address these challenges, institutions should invest in affordable AR tools, design user-friendly applications, provide comprehensive training programs, and promote a culture of innovation. By doing so, educators and students can unlock AR's full potential, fostering creativity, engagement, and deeper learning experiences in laboratory settings.

Impact of Augmented Reality on the Creative Process in Garment Design

Table III presents the comparative analysis of student outputs between traditional and AR-based methods, showcasing the transformative impact of Augmented Reality (AR) tools on garment design education.

The findings reveal a significant improvement in the creative process, with the total mean score increasing from 2.43 ("Needs Improvement") to 4.71 ("Exemplary") after the integration of AR tools. These results emphasize the effectiveness of AR in enhancing creativity, engagement, and technical precision, as supported by prior research.

Table Iii Comparative Analysis Of Student Outputs Between Traditional And Ar-Based Methods

Metric	Pre-Intervention Mean	Descriptive Interpretation	Post-Intervention Mean	Descriptive Interpretation	Mean Difference (D)	t-value	Significance (p-value)
Creative Process	2.43	Needs Improvement	4.71	Exemplary	2.29	12.38	**$p < 0.05$**

Note: 1.00–1.80- Poor, 1.81–2.60 - Needs Improvement, 2.61–3.40 – Satisfactory, 3.41–4.20- Proficient, and 4.21–5.00 - Exemplary.

Before the integration of AR tools, the pre-intervention mean score of 2.43, categorized as "Needs Improvement," indicated that students' creative processes were generally underdeveloped. This suggests that traditional teaching methods were insufficient in fostering students' ability to conceptualize and execute innovative designs. Existing literature consistently highlights the limitations of traditional methods in promoting creativity and engagement, emphasizing the lack of immersive and interactive experiences as a key barrier to innovation and technical skill development [13], [4]. Without the dynamic visual and interactive capabilities provided by AR, students struggled to elevate their outputs beyond basic levels of creativity and design quality. As Borisova et al. [4] noted, traditional methods often fail to provide the experiential learning opportunities necessary for students to connect theoretical knowledge with practical design applications.

Following the integration of AR tools, the post-intervention mean score increased significantly to 4.71, classified as "Exemplary." This remarkable improvement underscores the transformative impact of AR on the creative process, enabling students to conceptualize, refine, and execute their designs with greater precision, confidence, and creativity. The mean difference of 2.29 and the t-value of 12.38 ($p < 0.05$) indicate that the improvements were not only substantial but also statistically significant. These findings align with research by Borisova et al. [4] and Jalil [10], which highlight AR's ability to foster innovation and improve design accuracy through immersive visualization and interactive experiences. AR tools provided students with opportunities to experiment with design elements in real-time, enhancing their ability to refine and perfect their creative outputs.

The results also demonstrate AR's impact on streamlining the design process. Students were able to produce more complex and sophisticated outputs within shorter timeframes, addressing previous challenges related to time efficiency and design complexity. This aligns with findings by Liono et al. [16], who emphasized AR's ability to make the design process more intuitive and engaging, enabling students to complete tasks with greater efficiency and creativity. AR tools facilitated real-time feedback and visualization, allowing students to iterate quickly and refine their designs without the need for physical materials or lengthy trial-and-error processes.

Moreover, the motivational impact of AR was evident, as students demonstrated higher levels of engagement and creativity. The immersive and interactive nature of AR tools inspired students to explore creative possibilities, bridging the gap between theoretical knowledge and practical application. These findings are consistent with research by Kamińska et al. [13], which highlights AR's ability to transform learning environments and foster active student participation. As Mohamed and Sicklinger [18] observed, AR enhances learning outcomes by creating a stimulating environment that encourages students to experiment and innovate.

In conclusion, the integration of AR tools significantly enhanced the creative process in garment design education, enabling students to achieve higher levels of innovation, engagement, and technical competence. These findings contribute to the growing body of evidence supporting the use of AR in education and underscore its potential to revolutionize pedagogical strategies. By addressing the limitations of traditional methods, AR empowers students to meet the evolving demands of the fashion industry, preparing them for future careers in a

competitive and dynamic field. As Silvestri [28] noted, AR tools provide students with the skills and confidence needed to adapt to the rapidly digitized and globalized fashion landscape. Future research could explore the long-term impact of AR integration on students' professional skills, career readiness, and its potential applications in other areas of design education, such as interior design, product development, and architecture.

Enhancement of Learning and Skill Development Through Augmented Reality

The results of the study are presented from two complementary perspectives. Table 4 provides a quantitative comparison of students' knowledge and skills before and after the integration of Augmented Reality (AR) tools, analyzed using paired t-tests, which highlight measurable improvements in their learning outcomes. To complement these findings, Table 5 presents thematic insights derived from students and teachers, offering a deeper understanding of AR's impact on creativity, engagement, and skill acquisition in fashion design education. Together, these findings underscore the transformative role of AR in fostering meaningful learning experiences and practical skill development.

Table 4 presents the paired t-test results comparing students' knowledge and skills before and after the integration of AR tools into the learning process. The findings reveal statistically significant improvements in both areas, demonstrating AR's transformative impact on educational outcomes. Before the intervention, the mean score for knowledge was 2.50, categorized as "Needs Improvement," indicating that students struggled to grasp theoretical concepts and apply them effectively. Similarly, the pre-intervention mean score for skills development was 2.35, also classified as "Needs Improvement," reflecting challenges in achieving proficiency in the practical application of learned skills. These findings align with prior studies, such as Borisova et al. [13], which underscore the limitations of traditional teaching methods in fostering immersive and interactive learning experiences.

Table Iv Paired T-Tests Results Comparing Students' Knowledge And Skills Before And After Augmented Reality Integration

Indicator	Pre-Intervention	DI	Post-Intervention	DI	Mean Difference (D)	t-value	Significance (p-value)
Knowledge	2.50	Needs Improvement	4.80	Exemplary	2.30	11.85	$p < 0.05$
Skills Development	2.35	Needs Improvement	4.62	Exemplary	2.27	12.12	$p < 0.05$

Note: 1.00–1.80 - Poor, 1.81–2.60 - Needs Improvement, 2.61–3.40 – Satisfactory, 3.41–4.20 - Proficient, and 4.21–5.00 – Exemplary, DI-Descriptive Interpretation

Following the integration of AR tools, substantial improvements were observed in both indicators. The post-intervention mean score for knowledge increased to 4.80, classified as "Exemplary," while the mean score for skills development rose to 4.62, also categorized as "Exemplary." These results highlight AR's ability to enhance learning by providing students with dynamic visualizations and interactive tools that effectively bridge the gap between theoretical understanding and practical application. The mean differences of 2.30 for knowledge and 2.27 for skills development, along with t-values of 11.85 and 12.12 respectively ($p < 0.05$), confirm that these improvements are statistically significant. Such findings are consistent with research by Borisova et al. [4], which emphasizes AR's role in improving both comprehension and technical skills through immersive experiences.

The significant gains in knowledge and skills can be attributed to AR's unique features, such as real-time feedback and hands-on simulations, which enable students to refine their understanding and apply their learning in realistic scenarios. For example, AR fosters creativity and confidence by allowing learners to experiment safely within controlled environments, as noted by Jalil [9]. Additionally, AR's ability to enhance engagement and participation was evident in this study, with students demonstrating increased motivation and enthusiasm

toward learning. These findings align with Kamińska et al. [3], who highlighted AR's potential to transform traditional classrooms into dynamic spaces that inspire innovation and active participation.

Moreover, the motivational impact of AR was observed in the heightened enthusiasm and active participation of students throughout the learning process. The immersive nature of AR tools encouraged students to engage deeply with the material, fostering creativity and innovation. This is consistent with findings by Liono et al. [24], which demonstrate that AR-based learning models significantly enhance creativity and engagement among prospective educators.

In conclusion, the integration of AR tools significantly improved students' knowledge and skills, elevating their performance from "Needs Improvement" to "Exemplary" levels. These results underscore the transformative potential of AR in education, particularly in bridging the gap between theory and practice, enhancing engagement, and fostering technical competence. By addressing the shortcomings of traditional methods, AR empowers students to achieve higher levels of proficiency and prepares them to meet the demands of an increasingly competitive and dynamic professional landscape. Future research could explore the long-term impact of AR integration on students' career readiness and its applicability across other disciplines to further validate its effectiveness in diverse educational contexts.

Table V Insights From Students And Teachers On Augmented Reality's Impact On Learning And Skill Development

Table V provides insights from students and teachers on AR's impact, categorized into three themes: Amplified Cognitive Processing, Immersive Experiential Learning, and Safe Innovation Ecosystem. The findings reveal AR's potential to enhance visualization, engagement, and creativity in learning environments.

Themes	**Codes**	**F**	**%**	**Rank**
Amplified Cognitive Processing	Visualizing complex concepts in 3D	15	75%	1
	Transforming abstract ideas into tangible designs	12	60%	2
	Accelerating understanding through immersive visuals	10	50%	3
Immersive Experiential Learning	Engaging students through interactive simulations	14	70%	1
	Encouraging active participation in design tasks	11	55%	2
	Making learning enjoyable and memorable	8	40%	3
Safe Innovation Ecosystem	Facilitating risk-free experimentation	13	65%	1
	Developing technical skills through virtual practice	10	50%	2
	Fostering creativity in a controlled environment	6	30%	3

The most prominent insight identified in this study falls under Amplified Cognitive Processing, with 75% of respondents highlighting the ability of AR to visualize complex concepts in 3D as its most significant impact on learning and skill development in fashion design education. One teacher explained, *"AR allows students to see their garment designs in 3D before they even start sewing. They can visualize how different fabrics will drape and how the garment will fit on a virtual model, which helps them refine their designs early in the process."* Similarly, a student shared, *"I used AR to test different fabric textures and colors on my designs. Being able to see the results in real-time helped me make better decisions and improved my design skills."* Additionally, 60% of respondents noted how AR transforms abstract ideas into tangible designs, and 50% emphasized its role in accelerating understanding through immersive visuals. A teacher remarked, *"With AR, students can experiment with complex design elements like layering and embellishments without the need for physical materials. This not*

only saves time but also helps them understand how their designs will look and function in the real world." These findings align with Kamińska et al. [13], who emphasized AR's ability to enhance cognitive processing by making complex creative processes more accessible and interactive. Borisova et al. [4] also noted that AR tools in fashion education enable students to better comprehend complex garment construction processes by providing them with immersive, real-time visualizations.

Immersive Experiential Learning also emerged as a key insight, with 70% of respondents recognizing AR's ability to engage students through interactive simulations as its most impactful feature on learning and skill development in fashion design education. One teacher noted, *"AR enables students to simulate the entire design process, from sketching to virtual fitting, in a highly interactive way. This hands-on approach keeps them engaged and helps them connect theory to practice."* A student similarly shared, *"I used AR to create a virtual runway show for my designs. Seeing my garments in motion and on models helped me understand how they would perform in real life, which made the learning experience unforgettable."* Furthermore, 55% of respondents highlighted how AR encourages active participation in design tasks, and 40% emphasized its role in making learning enjoyable and memorable. A teacher remarked, *"AR makes the design process exciting for students. They're eager to experiment with different styles and techniques because the technology allows them to see the results instantly."* These findings are consistent with Cheng and Tsai [4], who noted that immersive experiences foster deeper learning by engaging students in realistic and meaningful ways. Similarly, Mohamed and Sicklinger [18] highlighted that AR facilitates experiential learning by providing students with virtual environments where they can explore and refine their creative ideas without the limitations of physical resources.

Another key insight relates to the Safe Innovation Ecosystem, with 65% of respondents emphasizing AR's ability to facilitate risk-free experimentation as its most valuable contribution to skill development in fashion design education. One teacher explained, *"AR gives students the freedom to try out bold design ideas without worrying about wasting materials or making costly mistakes. This encourages them to take creative risks and push their boundaries."* A student similarly shared, *"I was able to practice draping techniques on virtual mannequins in AR. It allowed me to experiment and improve my skills without the pressure of ruining expensive fabrics."* Additionally, 50% of respondents highlighted how AR develops technical skills through virtual practice, and 30% emphasized its role in fostering creativity in a controlled environment. A teacher remarked, *"By using AR, students can refine their skills in areas like pattern-making and garment construction before moving to physical prototypes. This not only builds their confidence but also enhances their technical precision."* These findings align with Bacca et al. [9], who stressed the importance of providing learners with safe and controlled environments to promote skill acquisition and innovation. Similarly, El-Nahass [7] noted that AR applications in fashion education allow students to experiment with various design techniques, such as pattern adjustments and fabric simulations, without incurring material costs or production delays.

AR's ability to foster creativity and innovation is particularly relevant in fashion education, where students are encouraged to push boundaries and explore new design possibilities. As Jalil [10] observed, AR has enabled the integration of traditional heritage into modern fashion design, allowing students to digitally preserve and experiment with cultural motifs in their creations. Silvestri [28] further emphasized the role of AR in reshaping the fashion industry post-COVID-19, as it provides students with the tools to adapt to a rapidly digitized and globalized design landscape. One student shared, *"Once I got comfortable using AR, I was able to create intricate designs that I never thought were possible before. The technology gave me the confidence to experiment and innovate."* Another teacher noted, *"Students are far more engaged during AR activities compared to traditional methods. They're excited to explore new techniques and see their designs come to life in a virtual environment, which leads to better learning outcomes."*

Despite these insights, challenges remain in fully integrating AR into fashion education. As Koumpouros [14] pointed out, the adoption of AR in education often faces technical, financial, and cultural barriers, which institutions must address to unlock its full potential. Perifanou et al. [23] similarly highlighted the need for comprehensive training and support for educators to effectively integrate AR tools into their teaching practices. By addressing these barriers—such as resource accessibility and cultural resistance—institutions can fully unlock AR's potential to enhance learning and skill development in fashion design education.

In summary, these findings reveal that AR's integration into fashion design education significantly amplifies cognitive processing, fosters immersive experiential learning, and creates a safe innovation ecosystem for skill development. By investing in user-friendly AR tools, providing comprehensive training and support, and promoting a culture of innovation, educators and students can leverage AR to transform learning experiences and foster creativity, confidence, and deeper understanding in fashion design.

CONCLUSION

Based on the findings of the study, several important conclusions are drawn regarding the integration of Augmented Reality (AR) in fashion design education. The study reveals that garment students have limited awareness of AR applications, with an overall mean score of 2.32, interpreted as "Unaware." While students showed moderate awareness of AR's accessibility on devices and its ability to enhance creativity, they lacked understanding of its technical aspects, immersive capabilities, and practical applications. This highlights the need for targeted educational initiatives to introduce students to AR tools, such as virtual fitting rooms, garment prototyping, and 3D visualization techniques, which are increasingly utilized in the fashion industry.

The integration of AR faces significant challenges, including a steep learning curve, high costs of hardware and software, insufficient institutional investment, and limited training opportunities. Resistance to shifting from traditional teaching methods also hinders adoption, with educators and students expressing concerns about AR's effectiveness and hesitance to embrace innovative technologies. These findings emphasize the importance of institutional support in addressing financial barriers, providing professional development programs, and designing user-friendly AR tools to facilitate adoption.

Despite these challenges, AR has a transformative impact on creativity in garment design education. The comparative analysis revealed a significant improvement in students' creative processes, with mean scores increasing from "Needs Improvement" (2.43) to "Exemplary" (4.71) after AR integration. AR enables students to visualize designs in 3D, experiment with textures and fabrics, and refine their ideas with greater precision and confidence. Its interactive and immersive nature fosters innovation, engagement, and efficiency, allowing students to produce more sophisticated and complex outputs within shorter timeframes.

Additionally, AR significantly enhances students' knowledge and skills, elevating their performance from "Needs Improvement" to "Exemplary" levels. Features such as real-time feedback, hands-on simulations, and interactive design environments improve technical proficiency while bridging the gap between theoretical understanding and practical application. Students perceive AR as an invaluable tool for developing practical skills, fostering creativity, and encouraging collaboration. The overall satisfaction score of 4.64 ("Strongly Agree") reflects the overwhelmingly positive impact of AR on their learning experiences.

In conclusion, while garment students demonstrate limited awareness of AR, its integration in fashion design education has proven effective in enhancing creativity, engagement, and technical competence. Addressing challenges related to awareness, accessibility, and training is crucial to unlocking AR's full potential. Institutions must invest in affordable tools, provide comprehensive training programs, and promote a culture of innovation to support AR adoption. By doing so, educators can prepare students for the evolving demands of the fashion industry, fostering career readiness and adaptability in a competitive field. Future research could explore the long-term impact of AR integration on professional skills, its scalability across other creative disciplines, and its role in promoting sustainable and innovative practices in fashion design education.

Limitations Of The Study

This study provides valuable insights into the use of Augmented Reality (AR) in fashion design education, but it has some limitations. First, the sample population was limited to garment students in a specific educational setting, which makes it difficult to apply the findings to other disciplines or institutions with different resources and technological access. Additionally, the study relied on self-reported data from students and teachers, which may be biased and not fully reflect the actual impact of AR on learning and skill development.

The study also focused on short-term improvements in creativity, learning, and skills but did not explore the long-term effects of AR on career readiness or professional growth. Differences in students' prior experience with digital tools were not considered, which might have influenced their ability to adapt to AR technologies. Furthermore, technical challenges, such as software compatibility, hardware reliability, and financial constraints, were acknowledged but not deeply analyzed, leaving questions about how these factors affect the scalability and accessibility of AR. The study also did not compare AR with other technologies like Virtual Reality (VR) or Artificial Intelligence (AI), which could provide alternative or complementary solutions.

Despite these limitations, the findings are still valuable and show that AR can significantly enhance creativity, engagement, and skill development. These results can serve as a foundation for adapting AR to other fields, such as architecture, engineering, medicine, or business, by tailoring the technology to meet specific learning goals.

Future research should address these limitations by including a more diverse sample of students from different disciplines and institutions, conducting long-term studies to assess the lasting impact of AR, and exploring technical and financial challenges in greater detail. Comparative studies with other technologies like VR and AI could also provide a broader understanding of how AR fits into education. Additionally, research should examine how cultural and regional differences influence the adoption and effectiveness of AR in various educational settings.

By addressing these gaps, future studies can provide a more comprehensive understanding of AR's potential, ensuring it becomes a powerful tool for learning and skill development across a wide range of disciplines and institutions.

RECOMMENDATIONS

Based on the findings and limitations of the study, several recommendations are proposed to enhance the integration of Augmented Reality (AR) in fashion design education. First, institutions should prioritize raising awareness of AR technologies among both students and educators by incorporating targeted workshops, training programs, and seminars. These initiatives should focus on introducing AR tools, such as virtual fitting rooms, garment prototyping software, and 3D visualization platforms, while emphasizing their practical applications in the fashion industry. By improving awareness, students and educators can better understand AR's potential to enhance creativity and learning outcomes.

Second, institutions must address the financial barriers associated with AR implementation by investing in affordable and accessible AR tools. Partnerships with technology providers, government funding, or industry sponsorships could help reduce costs and make AR technologies more accessible to underfunded institutions. Additionally, institutions should develop user-friendly AR platforms that require minimal technical expertise, ensuring ease of adoption for both educators and students.

To overcome the technical challenges highlighted in the study, institutions should provide comprehensive technical support and training to ensure smooth implementation of AR technologies. This includes addressing issues such as software compatibility, hardware reliability, and potential disruptions during use. Establishing dedicated teams for technical assistance and maintenance can help mitigate these challenges and foster a seamless learning experience.

Furthermore, future research should focus on conducting longitudinal studies to assess the long-term impact of AR on students' career readiness and professional development in the fashion industry. This would provide valuable insights into how AR-enhanced education translates into real-world applications and sustained performance. Researchers should also explore the effectiveness of AR in other creative disciplines, broadening the scope of its application and generalizability.

Finally, the study recommends exploring the integration of AR alongside other emerging technologies, such as Virtual Reality (VR) and Artificial Intelligence (AI), to identify complementary or alternative solutions for fashion design education. Comparative analyses of these technologies could provide a more comprehensive understanding of their individual and combined benefits, helping institutions make informed decisions about

adopting innovative tools. By implementing these recommendations, institutions can unlock the full potential of AR in fashion design education and better prepare students for the evolving demands of the industry.

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