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Emerging technologies in fashion design higher education courses
A narrative literature review

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Abstract: This article presents a narrative literature review on emerging technologies in fashion design education. The objectives aim to comprehend the technologies employed, how they have been integrated into pedagogical models in Fashion Design higher education courses, and the impact, challenges, and opportunities of these approaches for teaching and learning across various curriculum units in this field. The study was developed through a structured search strategy to find complete articles published between 2019 and 2023 in English and Portuguese in Web of Science, Scopus, and Scielo databases. The articles were categorized with the assistance of the Rayyan software, and selected works were input into the Mendeley software for managing readings. The most relevant information from the articles was identified, organized, and presented in the form of a review matrix to conduct the analysis and interpretation of data. The results highlight augmented reality and virtual reality as the predominant technologies in fashion design education, capable of enhancing teaching efficiency, stimulating creativity, and proving effective in developing specific skills. Challenges and opportunities point to the ongoing need for pedagogical innovation to maximize the potential of emerging technologies in higher education Fashion Design teaching.

Keywords: Emerging Technologies - Teaching - Fashion Design - Higher Education - Narrative Review

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1. Introduction

Technology can be defined as a collection of systems that build and adapt artifacts or tools to facilitate human life (Neira *et al*., 2017) or simply as a facilitator or vehicle used to disseminate knowledge (Oye *et al*., 2014). Although the use of technology in education is not recent, some technologies have shown disruptive potential and have caused transforma-

tions in educational processes, known as emerging technologies (ETs). Technology is not necessarily emerging due to its novelty, but rather because it has been employed for the first time in a particular context or used differently from before (Backhouse, 2013). ETs exhibit characteristics such as: a) adaptability to the needs of participants in the educational process; b) constant change and updating; c) ubiquity, being present everywhere as they overcome space and time constraints (Holotescu, 2015); d) providing new teaching methods for students to acquire the necessary skills for personal development in this digital age (Phillips & Berge, 2009).

Various emerging technologies have been incorporated into the educational landscape to increase effectiveness and enhance efficiency (Palanivel, 2020). Technologies such as the Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence, Cloud Computing, and Mobile Internet have a real possibility to add significant value to teaching and learning processes, making education innovative, more intuitive, and accessible.

Tools like ETs that could enhance the knowledge transmission system require careful consideration and must be developed in collaboration with the evolution of new teaching methods within a cohesive and well-structured educational system. The dissemination of these innovations has created an urgent need for research in the field to understand how students learn in the face of new resources and how they react and interact with emerging technologies in the classroom. Additionally, exploring how traditional teaching content can be recreated to be genuinely effective on new technological platforms and how teachers can leverage these tools to provide a more enriching and up-to-date educational experience is essential (Ngoc *et al*., 2020). These are pertinent questions to the addressed theme, which will be examined and analyzed throughout this work, specifically in the context of fashion education.

Thus, this article aimed to conduct a narrative literature review of emerging technologies incorporated into teaching models in higher education Fashion Design courses to identify the impacts of these approaches on teaching and learning in this field. Narrative literature reviews (NLR), often compared to qualitative summaries of existing and relevant literature, can combine studies addressing different questions and research methodologies (Baumeister, 2013). This narrative literature review is justified by the need to deepen specific knowledge, despite recent studies of this nature in the field of fashion (Baek *et al*., 2022; Mesjar *et al*., 2023; Prado *et al*., 2022; Theis *et al*., 2023;) addressing topics such as sustainability, teaching, product development, and technologies; they do not address the questions proposed by this work. Therefore, the intention is to build a foundation for future research since this type of review is characterized as an academic summary presenting aspects of the authors' interpretation and critique.

2. Emerging Technologies

This article considers emerging technologies as resources, artifacts, tools, concepts, and innovations associated with the digital realm, possessing the disruptive potential to trans-

form or instigate changes in the processes where they are employed, irrespective of whether they are new or old technologies (Neira *et al*., 2017). When applying this definition to education, emerging technologies aim to revolutionize teaching and learning, necessitating new classroom practices and strategies for teachers and students to incorporate technology. The following section will introduce some significant emerging technologies in the educational field.

- **Internet of Things**

The Internet of Things (IoT) is a digital era emerging technology that has brought Intelligence to objects by enabling the connection of people, objects, and devices. In education, IoT can monitor whether tasks assigned to students have been completed and the time taken for their completion. The data is captured, stored, processed, and analyzed to give the teacher a more detailed understanding of the students, assisting in identifying the most and least challenging activities, for instance. In infrastructure, IoT results in smart classrooms where lights automatically turn off in empty rooms, and thermostats can control and ensure the optimal temperature during classes. In education, IoT "enhances learning, adds efficiency, enables remote monitoring of activities, makes the environment more secure, tracks attendance and monitors in real-time" (Palanivel, 2020: 12).

- **Cloud computing**

Cloud computing is a technology that enables ubiquitous, convenient, and on-demand access to a shared pool of configurable computing resources, including networks, servers, applications, and services (Asadi *et al*., 2020). In education, cloud computing allows centralized data storage and online access to pedagogical services and resources. Another essential feature is its ability to facilitate collaboration without considering the physical distances between students and teachers, thereby establishing productive online communication among all education stakeholders. Cloud computing creates a flexible, unified, and open platform for educational information and the sharing of pedagogical resources among teachers, students, and developers (Palanivel, 2020). The benefits of using this type of system include reduced resource utilization, lower operational costs, increased accessibility to learning materials across institutions, and improvement in teaching and learning.

- **Mobile devices**

Mobile devices powered by wireless communication technology and embedded sensors have brought about a significant paradigm shift concerning the traditional face-to-face classroom. With limited resources and a teacher-centred approach, traditional learning has evolved into continuous learning that can take place anytime, anywhere, enriched by technology, and capable of blending real-world information with the digital realm. Smartphones and tablets enable the creation of an innovative, personalized, collaborative, interactive, and meaningful learning environment, allowing students to engage in activities that replicate real-world events (Catalano, 2015).

- **Artificial Intelligence**

Artificial Intelligence (AI) refers to electronic devices` logical ability to function like human thinking, such as understanding variables, reasoning, assimilating knowledge, solving problems, and making decisions (Ramos da Silva *et al.*, 2023). The term was coined by John McCarthy 1955, an assistant professor at Dartmouth College, who defined it as "making a machine behave in ways that would be called intelligent if a human were so behaving" (McCarthy *et al.*, 2006).

Artificial Intelligence has introduced robust educational methods, with a particular emphasis on efficient, personalized teaching, that has drastically transformed the learning experience for students. Possible applications of AI in education include adaptive learning, diagnostic tools, recommendation systems, virtual environments, identification of learning styles, gamification, and, notably, intelligent tutoring systems (Tavares *et al.*, 2020).

AI tools can make classrooms accessible to everyone, enabling synchronous participation of students who speak different languages or have visual and hearing impairments. However, using AI should not replace teachers. It should be viewed as a tool to assist them in providing personalized feedback, an assessment system integrated into the learning process itself and adapting recurring teaching methodologies (Cope *et al.*, 2021).

In the research field, AI enhances the efficiency and accuracy of data analysis by quickly processing large volumes of information, identifying patterns, and making more challenging correlations for humans to process. In addition to resulting in more efficient and practical research, researchers can allocate their time to more complex and creative tasks (Zhang & Pei, 2021).

- **Augmented Reality and Virtual Reality**

Augmented Reality (AR) was first used in 1992 to describe a technology developed by Thomas Caudell and David Mizell that allowed the visualization of virtual indications on the assembly of Boeing's aircraft cables (Caudell & Mizell, 1992). Since then, AR has influenced and benefited various fields such as industry, entertainment, marketing, medicine, maintenance, tourism, and education (Garzón, 2021; Kaliraj & Devi, 2022; Qiao *et al.*, 2019). Augmented Reality (AR) is a three-dimensional technology that enables individuals to comprehend the real world with the assistance of objects created in a virtual environment. Thus, what exists in the real world can be enhanced and more easily perceived with computer-generated information when there is an interaction between the user, reality, and virtuality (Garzón, 2021).

Augmented Reality (AR) occurs when digital content such as sounds, videos, texts, images, and animations are overlaid with the view of the real world (Peddie, 2017). In other words, it involves the integration of virtual content with the natural world for a sensory experience beyond reality (Qiao *et al.*, 2019). This overlay is made possible by computational technologies that project pre-created information onto images captured by digital devices in real-time and interactively (Peddie, 2017). The aim is to provide contextually relevant content beyond the material understanding (Qiao *et al.*, 2019). The growth of the smartphone industry has contributed to the development of AR, as the components used for AR are the same as those in mobile devices (Kaliraj & Devi, 2022). Currently, AR is not limited to the use of AR glasses or helmets. Tablets and smartphones allow users to

experience AR by capturing images with the camera and instantly projecting them onto the screen of these mobile devices (Peddie, 2017). For this, the device needs to detect the characteristics of the real object and present the virtual feature on the smartphone screen (Kaliraj & Devi, 2022).

In education, paradigms are being modified to include alternatives to physical classrooms in supporting traditional content delivery. In this way, AR has provided varying degrees of enhancement to the real world by integrating digital materials into pedagogical practices, allowing learning spaces to be more imaginative and collaborative (Holley & Hobbs, 2019). While there is great enthusiasm for this technology, there is also a lack of systematic understanding of what makes it effective or ineffective for education, as well as practical and comprehensive challenges when implementing it on a large scale in classroom environments (Radu *et al.*, 2022).

Augmented Reality (AR), like Virtual Reality (VR), can alter our perception of physical reality in the real environment, with some differences. VR transports our presence to another place, while AR 'augments' our perception of the world by adding relevant and contextualized information about what we can detect (Qiao *et al.*, 2019). With VR, the classroom can be transported to another location by using a virtual reality headset or mobile device to create a true immersion through 360-degree vision features and an immersive audio system (Donally, 2021).

Given this technology's possibilities, VR has been extensively explored in the educational context because, as a computer-generated digital environment, it allows experimentation and interaction as if this environment were real. In other words, it allows the student to immerse himself in a world beyond reality. Thus, VR "uses immersive technologies to simulate interactive virtual environments, or virtual worlds, with which users engage subjectively and in which they feel physically present" (Wohlgenannt *et al.*, 2020: 457).

Augmented reality has transformed the way teaching and learning occur (Peddie, 2017), as it fosters students' desire to comprehend and delve into the content by exploring the real world through resources that create the illusion of a 3D object in the classroom (Donally, 2021). Most research on implementing AR in education focuses on creating and evaluating teaching and learning experiences for students and professors in medical bachelor's programs (Bermejo *et al.*, 2023). According to a study that considered a database of 2023 academic papers, the most frequent knowledge area in the use of AR in education is the field of sciences, namely physics and biology (Radu *et al.*, 2022). Thus, there is an identified gap in the opportunity to study the implementation of technologies like AR and VR within the scope of Fashion Design undergraduate programs.

3. Emerging Technologies in Fashion Design Education

Research on using Augmented Reality (AR) in education is in its early stages and presents itself as a broad and promising field for investigation. Most studies in the last decade have been implemented through mobile devices (Geroimenko, 2020), as it is possible to create

this type of resource using both front and rear cameras, where the screen displays digitally integrated objects and information into the real world (Kaliraj & Devi, 2022).
Some advantages of using AR in education include increased student engagement in classes, greater motivation to learn, content retention, flexibility for teachers to create and adapt teaching materials, and the possibility of incorporating challenges into content and activities that typically capture students' attention (Donally, 2021).
Five studies have presented innovative proposals in the fashion design field by incorporating emerging technologies into the academic teaching and learning process. A study conducted at the Institute of Textiles and Clothing in Hong Kong aimed to assess the efficiency and learning experience of 90 fashion students in understanding complex issues by incorporating an AR application into a garment construction workshop. The study compared the results with a control group subjected to conventional pedagogical approaches (Yip *et al.*, 2019). The workshop covered topics such as threading a straight sewing machine, basic terminology, characteristics, and movements of the knitting needle in an industrial loom. The quantitative study revealed a significant difference between the two groups regarding understanding the proposed activity and providing a satisfactory learning experience. The study indicated greater learning efficiency in the experimental group that received technological educational resources, namely augmented reality videos (Yip *et al.*, 2019).
Another study at the University of Central Missouri aimed to compare students' performance in a sustainability teaching activity in fashion between a traditional approach and one that incorporated the use of a mobile application developed by Nike. The Making APP presents and classifies textile materials regarding the Material Sustainability Index (MSI) created by Nike over seven years of research and analysis (Abner & Baytar, 2019). In this experiment, 20 pairs of students were tasked with evaluating the environmental impact of nine clothing products. Initially without using the app and then again with the app. Subsequently, students created hypothetical products with at least three materials to result in items with low environmental impact. After administering questionnaires and analysis, it was found that students could more accurately assess the environmental impact of the presented products using the app. Additionally, the app allowed participants to complete the work more easily and with less frustration, develop more sustainable and creative products, and achieve higher evaluation grades (Abner & Baytar, 2019). In this study, mobile devices proved to be a useful technology for pedagogical proposals in sustainability, providing time savings in research and access to the information necessary to complete activities (Ordov *et al.*, 2019).
In a study conducted at the Fashion Design Course at the University of Najran, Saudi Arabia, the use of AR in fashion education was addressed through the Aurasma application installed on smartphones (Elfeky & Elbyaly, 2021). Aurasma is a free AR tool that allows users to link and overlay digital content onto objects, images, and locations from trigger images. The Aurasma app is user-friendly, provides a Web Studio for creating AR resources such as images, videos, audios, infographics, 3D objects, and web pages, and is available for both iOS and Android systems (Carvalho *et al.*, 2017). Therefore, it is considered one of the most widely used tools by teachers and students in an educational context.
The study aimed to evaluate the effectiveness of AR in promoting and developing the skills to create products with functional, aesthetic, and creative characteristics among 54 fashion

design students, randomly divided into two groups: a control group with traditional learning (educational videos available on the Blackboard system) and an experimental group with access to videos on the Aurasma app. By directing the smartphone to the image of the printed educational material, the technology displayed the tutorial video superimposed on the real image, allowing students to review the details of each drawing stroke easily. This mixed-method study demonstrated the added value of AR in this teaching area, promoting greater success and acceptance among students in all aspects, with a particularly positive impact on motivation and participant engagement (Elfeky & Elbyaly, 2021) *(See Figure 1 and 2).*

Figure 1 and 2. Aurasma in architecture (left) and Aurasma in fashion (right).

As a technology that encourages innovative exploration (Lau & Lee, 2015) and has great potential to influence the creative process of students in clothing design, the work carried out at the University of Nebraska-Lincoln in the United States sought to understand how university students perceived virtual reality (VR) technology used explicitly as a source of inspiration for creation (Starkey *et al*., 2021). After experiencing VR tools, 13 pairs of students created inspirational images and illustrations and materialized their ideas using the traditional three-dimensional modeling method. Ultimately, the products were crafted and presented at a fashion event. The study demonstrated that conceptualization and ideation could be developed more rapidly with VR) tools. VR proved helpful in stimulating imagination for generating new design ideas and possibilities (Starkey *et al*., 2021).
Another study that explored the use of VR in education, conducted at Yonsei University, South Korea, focused on fostering creativity and collaboration during the fashion design

process (Lee *et al*., 2021). There were 17 participants in this study, including 4 planners, 2 observers, 6 apprentice students (3rd-year fashion design students), and 5 experts. The proposed instructional model prototype and the resulting assessments provided new insights into the possibilities of using VR in the idea generation phase and fostering creativity in design *(See Figure 3 and 4)*. Additionally, participating students reported high satisfaction with the environment and educational methods of the proposed educational prototype. The study suggested that future research should be conducted on other phases of the fashion design process.

3

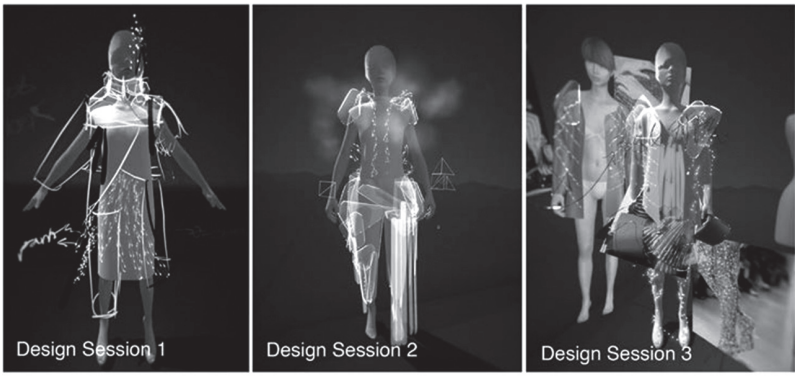

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Figure 3 and 4. Students and their drawings created with VR tool (Source: Lee *et al*., 2021).

These studies highlight the advantages of using technologies such as AR and VR in education. Among them are promoting student engagement, increasing flexibility in teaching and learning, and the challenges these new models still pose during the transition from the industrial to the digital era.

4. Methodology

To achieve the research objective of this study, a narrative literature review (NLR) was conducted, presenting initially the overall view (Flick, 2013) of the topic of interest and, subsequently, describing and discussing the state of the art from both a contextual and theoretical perspective (Rother, 2007). Developing this methodological section in this type of traditional review, including information on how the literature was searched, is recommended by some authors, not only for systematic reviews (Popay *et al*., 2006). It is emphasized that the state-of-the-art aims to identify the current understanding of the subject and provide insights into future research directions (Sukhera, 2022).
Although not requiring the presentation of the most rigorous aspects as in a systematic review, this narrative literature review was guided by the use of some research tools and instruments for a more meticulous definition of the works, such as the application Rayyan for assistance in selecting references and Mendeley for managing readings. The NLR followed the methodological path outlined in five stages proposed by (Sukhera, 2022). The five stages are defining the research question and target audience, conducting searches, selecting works, defining the sample, and analyzing and interpreting information. The stages and their developments are described below (Sukhera, 2022).

- **Definition of the Research Question**

Due to the need to explore the theme of using emerging technologies in teaching and learning in the academic context of Fashion Design, the following research questions were defined: How have emerging technologies been incorporated into the teaching models of Higher Education Fashion Design courses? What are the impacts of these approaches on the teaching and learning of different curricular units in this field?
Database Searches
The databases utilized in this research were Web of Science, Scielo, and Scopus. This selection was based on criteria prioritizing the quality and comprehensiveness of information sources. Among the characteristics of these databases, noteworthy features include multidisciplinarity, quality and reliability of works, comprehensiveness, advanced search functionalities, and continuous updates.
The search strategy was initially defined in English and combined the terms education, fashion design, higher education, college, university, and technology, using the Boolean operators AND and OR. The search string established in English and Portuguese was, respectively: education AND "fashion design*" AND ("higher education" OR "college" OR "universit*") AND technolog*; e educação AND "design de moda" AND ("ensino superior" OR "faculdade" OR "universidade") AND tecnolog*. Using the asterisk to the right

of some terms allowed for the retrieval of plurals or variations, as in the word technolog*, which made it possible to find variations like technology, technologies, technological, and technologically. The searches were conducted on September 18, 2023, and considered full articles published in the last five years (from 2019 to 2023).

- **Selection of Works**

In the Web of Science platform, the initial search yielded 138 articles, which, after refinement (excluding irrelevant categories such as fuel energy, etc.), concluded with a total of 120 works. In the Scopus database, using the criteria mentioned earlier, the search resulted in 9 articles. The Portuguese search string used in Scielo did not retrieve any articles. The numbers resulting from the search and selection process are organized in the following flowchart *(See Figure 5):*

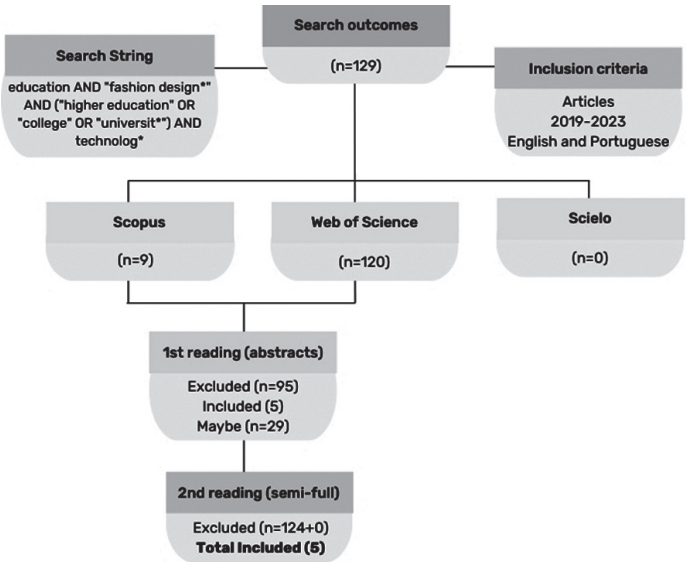

Figure 5.
Literature Selection Process (Source: Elaborated by the authors, 2024).

The 129 retrieved articles were imported into the free Rayyan application, where all authors could participate in the selecting works, making it a collaborative stage. Using Rayyan, initial readings were conducted, including titles and abstracts. At this stage, the works were classified as excluded (n=95), included (n=5), and maybe (n=29). This research considered incorporating investigations from any curricular units if they presented experiments in higher education with prototypes of teaching models involving emerging technologies.

The exclusion criteria adopted were for works that:

i. had a focus on software/technological tool training;
ii. were not applied research in higher education Fashion Design courses;
iii. did not involve emerging technologies;
iv. were not studies developed for face-to-face teaching modality;
v. were not studies about teaching/learning (education);
vi. did not present sufficient information (method/results);
vii. were duplicates.

The 29 papers classified as 'maybe' were semi-fully read, excluding the reading of literature reviews since they are usually present in studies to enhance knowledge about the study topics (Bogo *et al*., 2023) and not to expose the conducted procedures, the focus of this selection. None of these papers were included in the review because they were categorized according to the exclusion criteria previously outlined, resulting in the selection of 5 articles for this NLR.

- **Sampling Definition**

Although a narrative literature review is not required to include a comprehensive and exhaustive sample, it is necessary to describe the approach and factors influencing the selection of works (Sukhera, 2022). Thus, in this research, only full articles that presented experiments using educational materials and digital and/or technological resources for knowledge construction in fashion design courses, which typically still take on a traditional format (printed materials, task demonstrations, visualization of examples, explanatory exhibits, videos, among other examples) were considered. Works proposing pedagogical innovations and comparing educational prototypes with current academic resources and methods were prioritized. The exposition of the analysis between traditional and innovative models, the results of experiments, and the discussion of the potential of new proposals were considered essential for defining and selecting works.

- **Analysis and interpretation of data**

The five articles selected for this review were saved and included in the Mendeley software for managing readings, highlighting important passages, and making notes and comments. It was an iterative process involving reading, writing, and learning. After a complete reading, the information was structured using the synthesis matrix method proposed by Garrard (Garrard, 2021). The synthesis matrix (or review matrix) allows the researcher to engage with the literature and organize information relevant to the review's objective. The articles were arranged chronologically, and the collected data are presented in *Table 1*:

Table 1. Synthesis matrix (Source: Elaborated by the authors, 2024).

After constructing the synthesis matrix, it was possible to comprehensively understand the current integration of emerging technologies in Fashion Design education. This methodological approach facilitated the identification of existing gaps and contributed significantly to the theoretical foundation of this work.

Article	Objective	Technologies used, content	Participants, duration, location	Methods	Results
1 Yip et al. (2019)	Evaluate students` efficiency and learning experience in understanding complex issues through integrating an AR app in a garment workshop	APP for smartphones with AR videos Thread through the straight stitch machine; characteristics and movements of the knitting needle on an industrial loom	44 third-year students and 46 first-year students from the Institute of Textiles and Clothing at the Hong Kong Polytechnic University.	Quantitative study; control group; statistical analysis with IBM SPSS software; pre and post-test questions; randomized controlled trial (RCT)	Greater learning efficiency with the use of AR videos.
2 Abner (2019)	Compare the performance of students in a sustainability activity between a traditional approach and another that incorporated the use of Nike's Making app	Nike Making app for smartphones Textile sustainability/ sustainable fashion	20 pairs of students; two semesters; Fashion and Apparel Merchandising: University of Central Missouri	Action research; questionnaire with 6 open-ended questions; use of Nike's Materials Sustainability Index; McNemar's statistical test; SPSS software; qualitative data analysis (coding in 6 steps by Creswell, 2015)	Students were able to more accurately assess the environmental impact of products; completed the work with greater ease and less frustration; and developed hypothetical products that were more sustainable and creative when using the app.
3 Starkey & Alotaibi (2021)	Understand how university students perceive virtual reality (VR) technology as a source of inspiration for clothing design	VR headset; Apps with AR features; 2 tablets; smartphone; internet Creation and development of products	26 students (6 postgraduate and 20 undergraduate) enrolled in the Undergraduate Program in Experimental Apparel Design. During 1 semester. University of Nebraska-Lincoln/ USA	Qualitative and exploratory study; Observation of students; Textual analysis of open-ended questionnaire (before and after the project); Documentation of the design process; Reflections of the students	Conceptualization and ideation were done more quickly with VR tools. VR helped explore design principles and stimulate imagination (new ideas possibilities). VR proved to be a useful tool in apparel design classes
4 Elfeky &, Elbyaly (2021)	Investigate/ evaluate the effectiveness of Augmented Reality in developing the skills of fashion design students	Smartphones, AR, Aurasma App with tutorial videos, and Blackboard platform Fashion Design	54 students in the 2nd semester of higher education (divided into 2 groups); Duration: 1 semester (14 weeks); Fashion Design program at the Department of Home Economics, University of Najran	Case study; Qualitative study; Likert scale questionnaire; Statistical analysis with T-test; Use of Cronbach's alpha coefficient.	Products developed using AR achieved greater success and acceptance in functional, aesthetic, and creative aspects. AR proved to be effective in motivating, engaging, and attracting students

5 Lee et al. (2021)	Explore the use of Virtual Reality in creative education in fashion design, including collaborative exploration of the design process	VR; Clo3D and Tilt Brush Software; Mobile devices; HTC VIVE devices (VR tools); PC. Creativity in Design (Idea generation)	Instructional design team: 4 planners, 2 observers/evaluators, 6 apprentices (3rd-year fashion design students), and 5 experts. Yonsei University, South Korea	"R2D2 Method" (Willis, 2000); 4- phase creativity model (Wallas, 1926); Alpha test; Pilot test; Likert scale self- assessment questionnaire; Post-test interviews; Evaluation by observers and experts	VR fostered creativity in generating possible solutions for collaborative design. The VR environment provided new insights for future educational practices. Students reported high satisfaction with the environment and educational methods

Source: Elaborated by the authors (2024)

5. Results and Discussion

The analysis of the articles reveals convergences when stating that integrating emerging technologies, such as AR and VR, consistently shows improvements in teaching efficiency, student engagement, and creativity promotion. However, discussions also highlight challenges, emphasizing the need for specific pedagogical approaches and curriculum adaptations.

In narrative reviews, available scientific literature is synthesized, and no new data are presented (Bahl, 2023), justified by the need to explore a specific theme (Bogo *et al.*, 2023). Yip's study (2019) reveals the efficiency of using AR videos in garment workshops, highlighting a more dynamic learning experience and promoting an enhanced understanding of complex issues. Abner and Baytar (2019) addressed sustainability education in fashion, comparing traditional approaches with using a specific Nike application. The results indicate that incorporating technology facilitated environmental impact assessment and increased students' creativity, resulting in more sustainable products. Starkey and Alotaibi's study (2021) explored students' perception of VR technology as a source of inspiration for clothing design, indicating that VR tools accelerated the conceptualization and ideation process, proving useful in fashion design classes. Elfeky and Elbyaly (2021) investigated the effectiveness of AR in developing students' skills. They revealed that AR motivated, engaged, and attracted students, resulting in more successful functional, aesthetic, and creative products. Lee *et al.* (2021) explored the use of VR in creative education in fashion design, emphasizing collaboration in the design process. The results point to promoting students' creativity and providing valuable insights for future educational practices.

The use of AR in education is in an early stage (Geroimenko, 2020) and presents a promising field for investigation. Nevertheless, it became evident that AR positively impacted learning outcomes (Radu, 2012). Most studies in the last five years have implemented technologies in teaching through smartphones (Geroimenko, 2020) since they can act as a gateway to a new world of experiences and knowledge (Kaliraj and Devi, 2022).

The studies presented advantages of the use of AR, such as student engagement, increased motivation to learn, higher content retention rates, flexibility for teachers to create and adapt teaching materials, and the ease of incorporating challenges into the content and activities proposed in the curriculum. AR can provide step-by-step instructions in complex

tasks, making the teaching and learning process easier and safer (Suszek *et al*., 2023). The studies also reveal positive effects on collaborative experiences, ease in visualizing complex spatial relationships and abstract concepts (Arvanitis *et al*., 2009; Martín-Gutiérrez *et al*., 2010), the possibility of experiencing phenomena that are difficult or impossible to experiment with in the real world (Klopfer & Squire, 2008), ultimately, numerous positive effects on learning outcomes.

The observed gap lies in the need for more research that extensively explores the implementation of these technologies in Fashion Design disciplines in higher education, especially in units covering patternmaking and garment construction. It is crucial to fill this gap to provide specific insights tailored to this particular field's unique needs and characteristics. Regarding geographical limitations, the review highlighted studies predominantly conducted in educational institutions in countries such as Hong Kong, the United States, Saudi Arabia, and South Korea. However, there is a lack of investigations addressing the application of these technologies in more diverse geographical contexts. This gap hinders a comprehensive understanding of the challenges and opportunities that may arise in different educational environments, considering cultural variations, curriculum structures, and available resources.

Analyzing the selected articles reinforces the importance of carefully integrating emerging technologies into Fashion Design education. These tools not only facilitate the learning process but also act as catalysts for creativity and innovation, preparing students for the dynamic challenges of the contemporary fashion industry. The selected studies provided a detailed insight into the context, methodology, and results, which was essential to underpin the discussion in this section.

6. Conclusion

The narrative literature review undertaken aimed to explore how emerging technologies are being incorporated into the teaching models of higher education fashion design courses, explicitly focusing on the impact of these approaches on the teaching and learning of different curriculum units. This comprehensiveness was necessary due to limited publications on the subject of interest. Five of the initial 129 articles were selected for a more in-depth analysis, providing a focused insight into current practices. The analysis of the selected studies suggests that incorporating emerging technologies, such as AR and VR, offers significant benefits for fashion design education. Furthermore, mobile devices are widely used as a mediating and facilitating tool for AR technologies in the experiments presented in this review.

The effectiveness of the teaching and learning process, the promotion of creativity, the development of specific skills, and the addressing of contemporary issues, such as sustainability, underscore the crucial role of these technologies in transforming the academic environment. The successful integration of emerging technologies in this context can significantly enhance pedagogical effectiveness, fostering a more engaging and efficient learning environment.

Despite the potential demonstrated in the studies, challenges in transitioning from the industrial to the digital era and the need for pedagogical adaptation are still aspects to be considered. The research emphasizes the ongoing importance of pedagogical innovation and the development of effective strategies to fully harness the potential of these technologies in higher education fashion design.

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Resumen: Este artículo presenta una revisión narrativa de la literatura sobre las tecnologías emergentes en la enseñanza del diseño de moda. Los objetivos apuntan a comprender las tecnologías empleadas, cómo se han integrado en los modelos pedagógicos en los cursos de educación superior de Diseño de Moda, y el impacto, los desafíos y las oportunidades de estos enfoques para la enseñanza y el aprendizaje a través de diversas unidades curriculares en este campo. El estudio se desarrolló a través de una estrategia de búsqueda estructurada para encontrar artículos completos publicados entre 2019 y 2023 en inglés y

portugués en las bases de datos Web of Science, Scopus y Scielo. Los artículos se categorizaron con la ayuda del software Rayyan, y los trabajos seleccionados se introdujeron en el software Mendeley para la gestión de las lecturas. La información más relevante de los artículos se identificó, organizó y presentó en forma de matriz de revisión para llevar a cabo el análisis y la interpretación de los datos. Los resultados destacan la realidad aumentada y la realidad virtual como las tecnologías predominantes en la enseñanza del diseño de moda, capaces de mejorar la eficiencia de la enseñanza, estimular la creatividad y demostrar su eficacia en el desarrollo de competencias específicas. Los retos y oportunidades apuntan a la necesidad permanente de innovación pedagógica para maximizar el potencial de las tecnologías emergentes en la enseñanza superior del diseño de moda.

Palabras clave: Tecnologías emergentes - Enseñanza - Diseño de moda - Educación superior - Revisión narrativa

Resumo: Este artigo apresenta uma revisão narrativa da literatura acerca do uso das tecnologias emergentes no ensino do design de moda. Os objetivos passam por compreender quais as tecnologias utilizadas, como elas têm sido incorporadas aos modelos pedagógicos dos cursos superiores de Design de Moda, e qual o impacto, os desafios e oportunidades dessas abordagens para o ensino e aprendizagem nas diversas unidades curriculares que constituem esta área. O estudo foi desenvolvido a partir de uma estratégia de busca estruturada para encontrar artigos completos publicados entre 2019 e 2023, em inglês e português, nas bases de dados Web of Science, Scopus e Scielo. Os artigos foram categorizados com o auxílio do software Rayyan e os trabalhos selecionados foram inseridos no software Mendeley para gerir as leituras. Para conduzir a análise e interpretação dos dados, as informações mais relevantes dos artigos foram identificadas, organizadas e apresentadas em forma de matriz de revisão. Os resultados apontam a realidade aumentada e realidade virtual como as tecnologias predominantes no contexto do ensino do design de moda, capazes de promover melhorias na eficiência do ensino, estimulando a criatividade e revelando-se eficientes para desenvolver habilidades específicas. Desafios e oportunidades apontaram para a necessidade contínua de inovação pedagógica para maximizar o potencial das tecnologias emergentes no ensino superior de Design de Moda.

Palavras-chave: Tecnologias Emergentes - Ensino - Design de Moda - Revisão Narrativa