

Research in the Application of 3D Virtual Simulation Technology in Garment Construction Education: A Visualization Analysis Based on CiteSpace

Yupei Cao

School of Innovation and Creation Design, Shenzhen Polytechnic University, Shenzhen, Guangdong, 518000, China

ABSTRACT

With the development of digital technology in the fashion industry in recent years, the application of 3D virtual simulation technology in fashion design education has become an important research direction. As an important part of fashion design education, the application of 3D virtual simulation technology in garment construction has attracted extensive attention from researchers. Taking the research literature on "the application of 3D virtual simulation technology in garment construction education" as the research object, this paper uses the CiteSpace bibliometric visualization tool to review and analyze the research situations of domestic and foreign scholars published between 2010 and 2025. Based on the research theme, the keyword clustering, and the temporal evolution, the study explores the main research hotspots and development trends of the research. The results show that the research on the application of 3D virtual simulation technology in the education of fashion design has gradually changed from focusing on the tool level to reconstructing the teaching paradigm. For the Garment Construction, the current research hotspots mainly focus on the following four aspects: (1) the digital modeling and process reconstruction of garment structure; (2) the pedagogical application of virtual simulation in clothing structure teaching; (3) the innovation of curriculum system and talent cultivation mode; (4) cross-disciplinary integration and creative design. The research trend of the application of 3D virtual simulation technology in Garment Construction is expected to develop in the following directions: (1) Educational Mapping of Intelligent Manufacturing and Digital-Intelligent Industry Standards (2) Construction of Learning Paradigm of Digital Garment Holographic Structure Design (3) Dual-Competency Cultivation of Skills and Value Orientation. Overall, the results of this paper explore the development trend of garment construction towards the intelligent, cognitive, and value orientation, and provide a reference for the digital and intelligent development of fashion education.

KEYWORDS

3D virtual simulation technology; Garment construction; Cite space; Teaching reform; Research trends

1 Introduction

Given the rapid development of digital – intelligent convergence, the fashion industry is undergoing a profound transformation from a "experience-driven traditional design and manufacturing model" to a "system-based collaborative model empowered by data and responding to intelligence". In the fashion realm of Web 3.0, the metaverse has broken the traditional "production – consumption – reproduction" model. The continuous application of digital – intelligent technologies such as 3D digital fashion visualization, AI-based clothing design, virtual technology verification of patterns, and NFT product release has gradually increased the demand for digital fashion design talents with synergistic competencies in technology, design, and system aspects^[1].

In the past, the teaching model of "demonstrative instruction + passive reception" used in the garment construction course in university can no longer meet the needs of modern students for learning in a way that is engaging, interactive, and actively constructs knowledge. On the other hand, the Chinese government has proposed to accelerate the integration of information technology and education. In 2025, the Ministry of Education of China and eight ministries released the Opinions on Accelerating the Construction of Educational Digitalization. The document proposed to take the digitalization of education as a key breakthrough to open up a new way to promote the development of education, create new competitive advantages, and enhance the international influence of China in digital education. Under such background, this paper uses the CiteSpace knowledge-mapping analysis method to explore domestic and foreign researches on the application of 3D virtual simulation technology in fashion design education. Through a comprehensive analysis, this study identifies the development trajectory and key research hotspots in the field, highlights emerging frontiers in 3D virtual simulation technology applied to fashion design education, and offers insights that may inform future academic and industrial practices.

2 Data Sources and Research Methods

2.1 Data Collection

Over the past decade, research into the application of 3D digital virtual simulation technology in fashion design has gained increasing scholarly attention, characterized by a steady rise in annual publications and a progressive refinement of research directions. So This research chooses the literature published between 2013 and 2025, which are relevant to the research sample. Chinese literature comes from China National Knowledge Infrastructure (CNKI). The search query was set as: "3D 虚拟仿真" OR "三维虚拟仿真" OR "style3D" OR "数字化技术" OR "虚拟仿真技术" OR "数字孪生" AND "服装结构" OR "服装工艺" OR "服装制版" OR "服装结构与工艺" OR "服装技术" OR "服装教学". A total of 701 documents

were identified. Following the filtering of studies not belonging to the discipline “Light Industry and Handicraft” and restricting the document type to “academic journal”, and eliminating the irrelevant studies, the number of valid documents remained at 692.

English language literature was extracted from the WOS database based on the following search formula: ('CLO 3D' OR 'style3D' OR '3D virtual simulation' OR 'virtual reality' OR 'virtual fitting' OR 'virtual try-on' OR '3D garment simulation' OR '3D clothing CAD' OR '3D apparel CAD') AND ('garment construction*' OR 'pattern making*' OR 'apparel education' OR 'fashion education'). Finally, 384 documents were extracted.. After filtering the document type as “article” and “review”, and removing duplicate documents by CiteSpace, 157 valid documents were obtained..A total of 692 valid documents from China and 157 valid documents from English-speaking countries were taken as the final dataset of this study.

2.2 Research Methods

This study adopts case analysis and literature analysis methods to explore the current situation and research focuses on the application of 3D digital virtual simulation technology in clothing structure and technology-related courses. Using CiteSpace software, the visualization analysis of research on the application of 3D virtual simulation technology in teaching of garment construction is conducted. By adopting this method, the rapid and comprehensive understanding of the achievements made in the related field of educational research can be achieved, and the new situations and hot issues in the application of 3D digital virtual simulation in fashion can be summarized. The 692 Chinese documents from CNKI and 157 English documents from WOS were imported into CiteSpace. The time slicing was set from January 2005 to December 2024. The term sources included Title, Abstract and Keywords Plus. The bibliometric analysis was conducted from three perspectives of publication volume, keywords and temporal evolution of research hotspots. Then, the application and research situation of 3D digital virtual simulation technology in garment construction education were systematically studied.

3 Visualization and Bibliometric Analysis of Research on 3D Virtual Simulation Technology in Fashion Design Education Based on Citespace

3.1 Analysis of Research Publication Trends on 3D Virtual Simulation Technology in Fashion Design Education

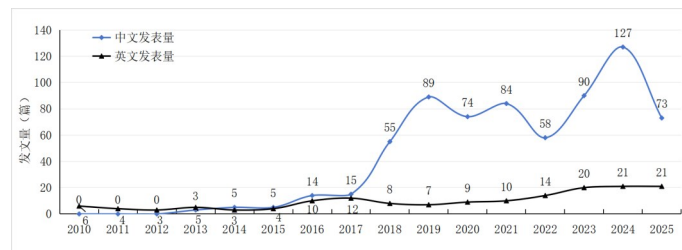


Figure 1 Publication Volume of Research on the Application of 3D Digital Virtual Simulation Technology in Fashion Design Courses (2010–2025)

By statistical analysis of the related literature, the trend line chart showing the changes of publication volume with application of 3D digital virtual simulation technology in garment construction course was drawn (shown in Fig. 1). The research output in this field went through four different stages: low and stable period (2010–2017), steady period (2017–2022), fast-growing period (2022–2024), and high-level correction period (2024–2025).

In this section, we will analyze these four periods and their driving factors. These drivers are closely related to the development of apparel industry and digital technology. From 2010 to 2017, virtual simulation technology was not yet widely applied in fashion design education around the world [6]. The research on application and optimization of relatively popular two-dimensional computer-aided design (CAD) software in pattern making was the mainstream in this period. Since the digital 3D technology was not widely used in production, the research on the application of 3D virtual simulation in teaching of garment construction course was still in the initial stage, and the publication volume was still very low. Since 2017, the global overproduction appeared in the fashion industry, and the sustainable fashion design gradually attracted more attention. The academia began to focus on the application of virtual 3D digital tools in the field of fashion design and production, and university teachers also began to try to use 3D garment simulation platform in teaching and laboratory teaching. Therefore, the number of related publications increased gradually in this period. It is still an accumulation period [17]. In 2021, the occurrence of COVID-19 pandemic changed the consumption and production pattern of the whole world. The demand of online virtual fitting, digital sample presentation, and online virtual teaching applications exploded. The advanced digital technology such as artificial intelligence, digital twin, and smart textile were rapidly applied in the textile and apparel industry. This changed the traditional production method and teaching method

of apparel industry, and provided new ideas for the research on course design and teaching method. In addition, guided by the national policy of transforming fashion education into “New Engineering Disciplines” and “Digital – Intelligent Integration”, the research output of domestic scholars also jumped up and reached the highest in 2023 and 2024. Until 2025, following the rapid development in 2023 and 2024, the publication volume showed a slight decline, but it was still much more than before 2020. Most of the teachers have shifted their research focus to new interdisciplinary research areas such as AI-assisted design, intelligent manufacturing, and sustainable design.

3.2 Analysis of Research Hotspot Areas

3.2.1 Keyword Clustering Analysis

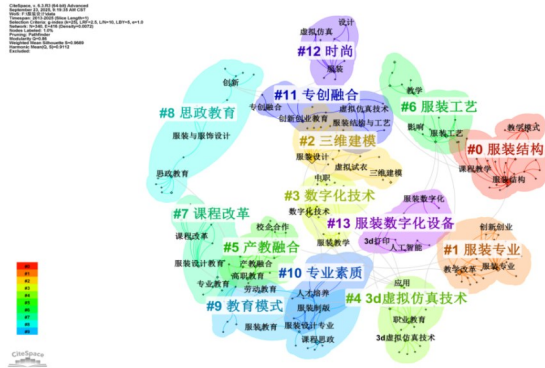


Figure 2 Keyword clustering map of Chinese literature

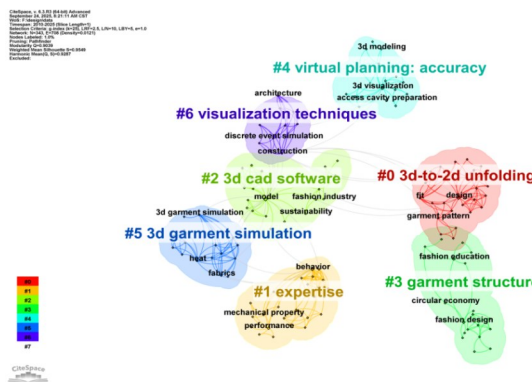


Figure 3 Keyword Clustering Map of English Literature

Keywords can be regarded as the simple and accurate summaries of the main content of a study, and can reflect the main research content and research direction in a certain research field. By conducting co-occurrence clustering analysis of high-frequency keywords of application research on 3D virtual simulation technology in fashion design, the main research hotspots in this field are identified. The keyword clustering analysis was carried out on 692 Chinese publications and 157 English publications in the research scope based on CiteSpace by using LLR (Log-Likelihood Ratio) clustering algorithm. The results of keyword clustering model are shown in Figure 2 and Figure 3.

In the keyword clustering model, Q value (modularity) and S value (mean silhouette score) represent the clustering quality and credibility of the model, respectively. When Q value is larger than 0.3, there is significant cluster structure; when S value is larger than 0.5, it indicates that the result is highly reliable. The results of the modularity Q value in this study were 0.86 and 0.9039, and the average silhouette S value were 0.9689 and 0.9549, indicating that the clustering results were reasonable and convincing.

A total of 14 clusters were identified in the Chinese literature and 7 clusters in the English literature based on the keyword clustering analysis. Through overall analysis and discussion, the four main thematic development directions of current domestic and international research on 3D virtual simulation of fashion design can be summarized as follows: ① Digital Modeling and Process Reconstruction of Garment Structures (#0 Clothing structure; #2 3D modeling; #3 Digital technology; #6 Garment technology; #0 3D-to-2D unfolding; #2 3D CAD software; #3 Garment structure) ② Applications of 3D Virtual Simulation in Teaching (#4 3D virtual simulation technology; #7 Curriculum reform; #9 Educational model; #13 Digital equipment in fashion education; #4 Virtual planning: accuracy; #5 3D garment simulation; #6 Visualization techniques) ③ Educational Models for Fashion Majors (#1 Fashion major; #5 Industry – education integration; #8 Ideological and political education; #10 Professional competence; #1 Expertise) ④ Innovative Talent Cultivation, Interdisciplinary Integration, and Creative Fashion Design (#11 Integration of innovation and entrepreneurship education).

Firstly, in terms of specific research content, international scholars mainly concentrate on digital modeling and process reconstruction of garment structure in theories of human – fabric – environment coupling, virtual derivation of fabric parameters, experiential quality of virtual prototype garment and pedagogic and validation value of modeling method. Researchers from Romania have put forward various modeling methods and garment simulations in virtual environment and stressed that modeling method has important pedagogic value and rapid validation value in teaching [2]. Likewise, Kim and LaBat (2013) from Korea and the United States have studied the application of 3D body scanning and virtual fitting in consumers’ experience of fit perception, satisfaction and willingness for future use and confirmed that virtual modeling technology has important application value in teaching and consumer field [3].

Compared with them, Chinese scholars focus more on dynamic translation of 2D pattern and 3D garment, substitutive and optimizing function of virtual prototype garment in teaching and application of digital simulation in cultivating students’ structural reasoning thinking and creative design ability. Garment construction course are generally highly abstract and difficult for students to understand basic structural theory intuitively and visualize the whole process of digital transformation from 2D pattern to 3D garment easily. Li Xiaojing (2022) adopted virtual simulation technology to solve the problem of difficulty in understanding the logic between structure and body proportion in teaching [4]. And then Liu Jia (2024) pointed out that virtual simulation can not only motivate students’ learning motivation and skills but also bring greater visualization and interaction in teaching of garment technology [5].

Secondly, in terms of application of 3D virtual simulation in teaching, Chinese researchers mainly concentrate on visualization of whole teaching process, new interactive learning mode and improvement of teaching effect and sustainability. Wang Wei (2022) used virtual simulation experiment to realize visualization of whole process of fashion design from conception, pattern making to sewing, presentation and operation and then solved the problem of “inaccessible, invisible, immovable and incomplete learning” existing in traditional instructional mode [2].

From the perspective of international advanced researchers worldwide, they focus more on visualization of structural logic, pedagogic effectiveness of virtual garment simulation, cultivation of creative space design thinking and immersive and interdisciplinary learning mode. Choi, K. H. et al., scholars from the United Kingdom studied how to apply 3D dynamic simulation technology in application of fashion design and development and defined that virtual simulation can not only be used in creative thinking training but also can change the learning mode of students from “imitation and repetition” to “exploration and creation” [6].

At the Swiss Federal Institute of Technology Zurich (ETH Zurich), Nico Pietroni who has been working in the field of computer graphics and digital fashion for a long time proposed a computationally reverse-generated 2D pattern method based on 3D garment models . He designed an interactive virtual simulation system. The system can automatically generate patterns based on 3D garments, and designers can draw seam lines or modify parameters directly on the garment model. The iterative interaction is possible with this system, and learning efficiency in garment structure design courses is significantly improved. Beginning students can generate patterns quickly and modify them easily virtually with this method; therefore, the learning threshold is significantly lowered [7].

Finally, in terms of fashion education models, talent cultivation, interdisciplinary integration, and innovative fashion design, Chinese scholars focus more on the reconstruction of the curriculum system, the integration of virtual simulation technology with a value-oriented model of talent cultivation [8]. In contrast, foreign scholars focus more on interdisciplinary integration and the cultivation of creative thinking. They cultivate interdisciplinary learning and innovation in fashion design education through the integration of 3D virtual simulation and computer technologies to promote fashion design education towards a learning mode oriented to innovation and cooperation.

3.2.2 Evolution of Research Hotspots

The timeline view is used to show the relationships among clusters and the publication years of clusters. Through the

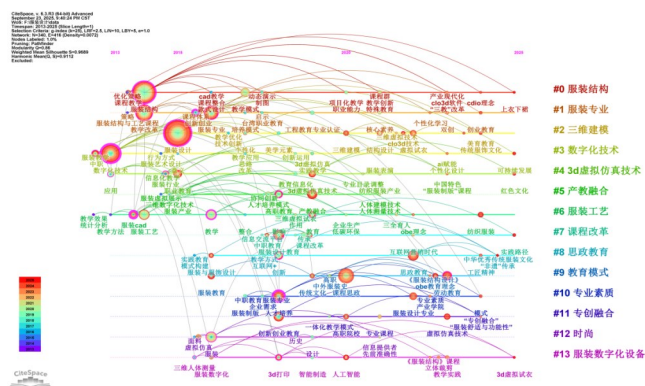


Figure 4 Timeline of Keywords in Chinese Literature

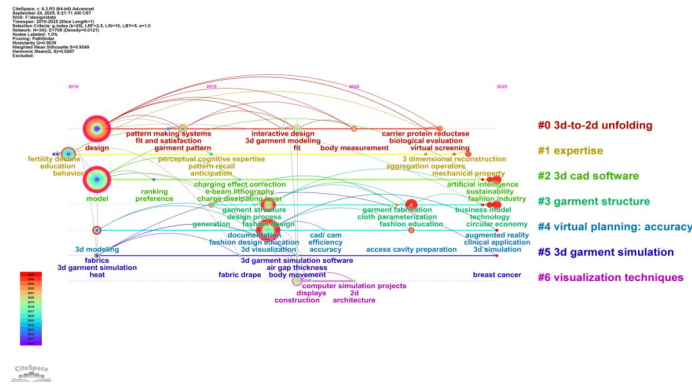


Figure 5 Timeline of Keywords in English Literature

timeline visualization, we can find out the main keywords in each cluster, the publication years of these clusters, and the relationships between clusters. As shown in Figure 4, the keyword-based visual timeline of CiteSpace generated the timeline visualization of the evolution of research hotspots in the field as follows. The position of each node represents the publication year when each keyword first appeared in the literature. The connecting line represents the evolution of the research focus at the time .

In China, research on the application of 3D virtual simulation technology in garment construction education evolved from the developmental track of digital modeling exploration to the integrated pedagogical design using virtual simulation. In the initial stage (2007–2012), research focused on the digital translation exploration of CAD drafting and two-dimensional pattern making. In 2013–2017, keywords such as “3D modeling” and “curriculum reform” appeared, which represented that the 3D simulation technology was applied in classroom teaching. In 2018–2021, with the appearance of keywords such as “intelligent manufacturing” and “industry–education integration”, the research focused on constructing teaching practices based on virtual simulation. After 2022, the keywords such as “3D virtual simulation technology” and “digital fashion equipment” appeared frequently, which represented that the research based on virtual simulation in garment construction education entered the new stage of curriculum reconstruction and competency-based education based on virtual simulation in recent years. Differently, the research in foreign countries focused on cognitive training and interdisciplinary learning experiences. The research on 3D virtual simulation technology abroad appeared earlier than that in China. The research presents a clear evolutionary trend from the technical validation stage to the education integration stage, and then to the immersive experience stage, and at last to the sustainable development stage. From 2005 to 2013, the research represented by the keyword such as “garment simulation” and “fabric drape” focused on the accuracy of simulation and the physical reality of computational modeling experiments. From 2014 to 2017, the keywords such as “fashion education” and “interactive design” appeared frequently, which represented that the 3D simulation technology was officially applied in design education. From 2018 to 2022, the keywords such as “AR/VR visualization” and “virtual planning” appeared, which represented that the attention to interactive learning and spatial cognition development gradually increased. In recent years, the keywords such as “expertise” and “sustainability” appeared, which represented that the research entered the new stage of convergence based on virtual simulation, creative thinking, sustainable education, and interdisciplinary innovation.

4 Current Issues and Research Gaps in the Application of 3D Virtual Simulation Technology in Garment Construction Education

4.1 Major Pedagogical Problems in the Teaching of Garment Construction Courses in Universities

Garment Construction Courses is one of the basic technical courses in the university fashion and apparel design programs. After several rounds of course reformations and continuous iterations, its teaching contents have become relatively mature and fixed in recent years. However, such “fixedness” has caused a significant gap between the garment construction course and the dynamic changes in the fashion market and industry. Students often complain that the course is “outdated, slow, and uninteresting in this modern era”. Based on the review of domestic and foreign research literature, the author believes that the following issues currently exist in the garment construction course teaching. First, the learning objectives are too skill-oriented, and the logical definition of structural understanding is weakened. The teaching target of garment construction course is still on learning the basic process of structural design and sewing. However, one of the most difficult parts for students to accept is the logical definition of garment shaping and relationships among data parameters. Many students feel confused about the mapping relationship between two-dimensional pattern and three-dimensional body and only memorize formulas in rote learning rather than logical thinking. Second, the content is behind the frontiers of industry, and the degree of education-industry integration is

insufficient. Only when the fashion designer can control the detailed garment ease and the fashionable trends can he/she know structural design. Structural data details of each fashion season can inspire new innovative silhouette. However, the content of garment construction course is still too static. The styles and cases of structural data presented in class are usually not very fashionable and lack real-time application. Third, the teaching methods are linear and lack interaction. The traditional method of clothing structure teaching has long been “teacher demonstration → student imitation → repeated practice”. Such linear and unidirectional model lacks problem solving in specific context and inquiry learning. It is difficult to stimulate the initiative, critical thinking, and ability to apply knowledge in various situations. Fourth, there is a misalignment between domestic and international emphases. The comparison of apparel technology courses of all fashion institutions in the world shows that in some advanced schools in Japan and Italy, technical instruction plays the role of an intermediary module that directly serves creative design—every technical process serves innovation. However, our traditional clothing structure technology courses have two different learning objectives: (1) cultivate structural creativity and design ability in fashion design majors; (2) provide basic technical knowledge for future pattern makers. This separation will weaken the logical connection between technical learning and creative learning. Fifth, there are shortages of qualified teachers and digital equipment. The teaching staff of this course still has certain limitations: some teachers lack enough industry experience, so it is difficult to summarize the key ideas from the point of view of experienced brand designers. In addition, the shortage of advanced digital equipment and simulation rooms limits the implementation of modern and interactive teaching..

4.2 Misconceptions in the Research and Practice of Applying 3D Virtual Simulation Technology in Garment Construction Education

Based on the CiteSpace based bibliometric analysis of relevant Chinese and English published literature, the result shows that the current research on 3D virtual simulation technology application in fashion design is gradually developing in multidisciplinary and diversified directions with more rich research methods, and the research focus is not only limited in the technical application research of 3D virtual simulation software, but also extended to more advanced research such as teaching context construction, optimization of cognitive process and comprehensive innovation ability cultivation. However, the author believes that there are still some basic misunderstandings in the current research on pedagogical application of 3D digital virtual simulation technology in fashion teaching.

4.2.1 Misconception One: Thematic Homogeneity — Overemphasis on Operational Efficiency

Intensification Based on Bibliometric Analysis of the Redundancy of Study Topics in Chinese-Language Papers on the Application of 3D Virtual Simulation Technology in Garment Construction Education.

A large number of papers share highly similar titles, and the research ideas of these papers are very similar. There is little innovation. Most studies primarily focus on introducing the operational procedures of using 3D fashion design software packages and trying to show how to be applied in classes, but few of them can design an integrated instruction or an interdisciplinary instruction model. In their research, most scholars regard CLO 3D and Style3D as digital modeling technical training software and attempt to use 3D virtual simulation platforms to create a virtual display platform for design results. They fail to explore how to use virtual simulation to enhance students’ understanding of garment structure and promote their creative thinking. Using digital simulation to make operational demonstrations is narrow-minded pursuit of efficiency improvement. Garment structure and modeling logic are still simple and imitative understanding of students. In addition, pursuing efficiency improvement of technical training or results-oriented assessment will make virtual simulation become a formality substitute for real learning. The true value of using 3D virtual simulation technology does not lie in pursuing operational efficiency, but reconstruction of the learning process to understand garment structure and exploration of spatial imagination and innovative design thinking..

4.2.2 Misconception Two: "Virtual Transfer" of Content — Misalignment Between Methods and Cognitive Logic

In response to national initiatives such as Guidelines for High-Quality Development of Smart Education and Establishment of the National Smart Education Platform, some universities have promoted garment construction courses onto platforms such as MOOC, Xueyin Online, and National First-Class Courses. As a result, superficial migration of teaching resources has occurred. That is, some teachers merely record their existing offline courses or demonstrate physical objects by transferring them into animations and uploading them online. They present the same traditional garment construction course in a virtual environment without adjusting their teaching objectives, instructional design, cognitive scaffolding, or interaction mechanism with digital tools.

The majority of existing studies on 3D virtual simulation teaching focus on developing digital case libraries for 3D garment construction. However, the presented cases seldom contain interactive simulation modules that can guide students through reasoning processes based on structural logic, nor do they contain reverse analysis and error reflection modules that prompt students to reflect on their mistakes and understand why they are incorrect. As such, students are unable to perceive the logic behind the garment construction. In turn, virtual simulation is superficial and merely a

demonstrative form used to showcase the logic behind garment construction, rather than an effective cognitive scaffold that can train students to engage in structural reasoning and design thinking.

4.2.3 Misconception Three: Neglect of Technical Cognition — Virtual Simulation Reduced to a Display and Assessment Tool

With the increasing implementation of digital 3D simulation in fashion education, an increasing number of scholars have started to challenge the necessity of technical training for fashion design students. Some scholars even proposed that “digital simulation could replace physical practice.” Some argue that, as the fashion industry undergoes a digital–intelligent transformation, training in 3D virtual garment modeling has become more essential than mastering manual pattern-making and sewing skills. This view was particularly popular in March 2020 when the global outbreak of the novel coronavirus forced us to quarantine at home and virtual teaching became an effective solution to equipment and space limitations. Instead of evaluating students’ achievement in garment construction courses based on the final results of 3D digital modelling, considering that the essence of value in teaching these courses was never on the execution skill, but on the process of students’ cognitive transformation from two-dimensional to three-dimensional form, the awareness of fabric property and structural process, the essence of teaching in garment construction courses lies not in the completion of technical tasks but in cultivating students’ cognitive transformation from two-dimensional patterns to three-dimensional forms, their awareness of fabric–structure relationships, and their aesthetic sensitivity to pattern structure and garment design. Therefore, treating 3D digital modeling results as the sole criterion for evaluating students’ achievement in these courses represents a serious pedagogical misconception. As Professor Choi Kyung-Hee from Hanseong University (2022) believed, although 3D garment modelling can greatly improve students’ visual communication and digital skills, depending too much on 3D garment modelling will weaken their intuitive judgement and creative flexibility when facing real cloth and garment design challenges^[9]. Therefore, although virtual simulation brings unprecedented opportunities to fashion education, teachers should not ignore students’ hands and material manipulation learning to avoid the loss of tactile sensation and cognitive thinking that can only be brought by virtual simulation in building true structural understanding and craftsmanship in fashion education.

5 Trends and New Pathways in Research on 3D Virtual Simulation for Garment Construction Education

5.1 New Industrial Standards Driven by Intelligent Manufacturing and the Digital–intelligence Revolution



Figure 6 KUKA Germany: Fully Automated Sewing Robots and 3D Body Scanning Technology

In terms of theoretical knowledge instruction in clothing technology courses, the teaching content has long been too “abstract” and “fragmented.” In addition, the traditional “demonstration–imitation–repetition” teaching mode often results in students’ inability to possess sufficient technological adaptability to meet future work requirements. However, new production ways and new consumption ways constantly generate new technological application scenarios. In the past, what appeared to be “utopian” in reality now has already become “reality.” That is, the integration of 3D virtual simulation visualization with VR and AR technologies to model intelligent, flexible garment manufacturing workshops and hanging production lines, as well as AI-based robotic cutting and sewing and smart fitting and digital body measurement, are already moving from concept to reality (see figure). However, the physical training facilities provided by most universities are unable to recreate these advanced industrial environments or support the cultivation of corresponding professional competencies. Therefore, the core issue that fashion education faces today is how to make the abstract technical theories appear in 3D virtual visualization and place them in realistic industrial scenarios that promote applied learning and professional readiness. It is clear that digital 3D virtual simulation, digital twin systems, and VR/AR

technologies can solve this pedagogic problem from the perspective of teaching content. For example, Green Brothers Technology Co., Ltd. (Shenzhen) has designed an immersive VR-based intelligent garment production factory system aimed at fashion programs at the university level. Students can experience the entire workflow of an intelligent garment manufacturing facility in a campus training facility (see Figure 7). Based on these detailed virtual scenario designs, instructors organize interactive and experiential teaching units that enable students to immerse themselves in an industry-simulated ecosystem. Within this environment, students engage in garment structural decision-making, conduct virtual disassembly and process analysis, and develop collaborative design workflow capabilities. Through such experiential learning, students cultivate critical thinking, structural reasoning, and design coordination skills within a realistic digitally simulated industrial context.



Figure 7 3D Virtual Simulation System for Intelligent Garment Manufacturing

5.2 Constructing a New Holographic Learning Paradigm in Garment Construction Education through Digital Sample Garment Modeling



Figure 8 Holographic AR Garment Structure Reverse Disassembly System and 3D Digital Virtual Simulation Case of Garment Structures

In traditional garment construction education, the predominant instructional model is characterized by a “teacher demonstration plus student imitation” approach, in which learning objectives are narrowly defined as the mastery of a predetermined set of operational steps. Within this framework, students act as passive recipients of standardized rules for pattern drafting and sewing processes, while instructors deliver formulaic content aimed at achieving uniform learning outcomes. This linear and procedural mode of teaching weakens the pedagogical connection between fundamental theories of garment construction and the creative structural challenges encountered in contemporary design practice. It also overlooks the cultivation of students’ creative structural development and spatial visualization skills. According to the author’s investigation, many fashion design students experience difficulties in mastering key structural principles such as dart manipulation and shaping, body-surface fitting, and proportional coordination in garment construction. Field research conducted by the author reveals that many fashion design students experience considerable difficulty in mastering fundamental concepts such as dart manipulation and shaping, body-surface fitting, and proportional coordination within garment structures.

Given the limitations of traditional teaching methods in cultivating students’ cognitive understanding of garment structure and creative capability, recent advances in AR-based digital technologies and 3D garment modeling software have highlighted the urgent need to establish a holographic learning paradigm for fashion structure education—a digitally driven, multidimensional, process-oriented, and visually interactive pedagogical model. Based on virtual 3D simulation platforms, this new learning model innovatively proposes a new type of learning method that uses reverse reasoning with visualization of structural rules, providing students with a new cognitive route to understand garment structure and form. Students can virtually dissect a complete three-dimensional garment model and clearly see the spatial and morphological relationships between individual pattern pieces and the curved surfaces of the human body. More importantly, this model breaks away from the traditional “forward construction” mindset. During the deconstruction process, students establish a perceptual awareness of spatial composition and actively reflect on the intrinsic relationship between structural rules and human anatomy (see Figure 8).

5.3 Visualization and Cognitive Innovation in Problem Recognition Within Virtual Garment Construction

In higher education programs for fashion and apparel design, garment construction serves as a critical bridge between a designer's conceptual sketches and the realization of finished garments. It represents one of the essential professional competencies required of a qualified fashion designer. In today's textile and apparel industry—profoundly reshaped by digital technologies—some experts have questioned the necessity of teaching garment construction, dismissing it as an outdated manual practice. However, for students with an artistic or design-oriented background, garment construction is far from obsolete. It is not merely a process of mastering sewing sequences or basic operational techniques, but rather a creative catalyst that enables students to experiment through craft-based trial and error and engage in aesthetic transformation during the realization phase of design.

With the application of 3D virtual simulation technology in garment construction education, students can intuitively understand the inner mechanism of sewing machine and whole virtual garment construction process through animated 3D virtual simulation. In addition, the virtual simulation technology can also dynamically display various process errors that happen in practice (such as stitch distortion due to thread tension problem or fabric deviation due to uneven gathering). Students can “see” these issues happen virtually, analyze the malfunction reason and then reverse engineering the technical adjustment to correct them.

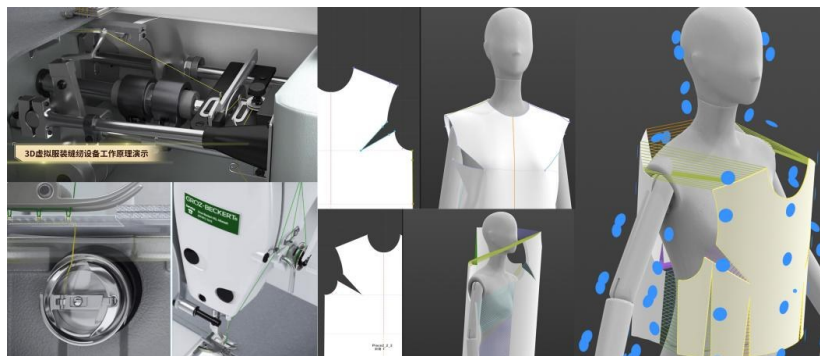


Figure9 3D Virtual Simulation of Sewing Machine Motion and Virtual Sewing Simulation in Style3D Software

5.4 Reconstructing Dual Competence in Skill and Value Through 3D Virtual Simulation – driven Design Education

With the publication of authoritative documents such as the UN Sustainable Fashion Communication Playbook in 2023, "design-driven innovation" and "sustainable strategic transformation" have emerged as core developmental objectives for the global fashion industry. Within this context, garment construction and technology courses, as foundational components of fashion design education, urgently require a paradigmatic shift from "skill-oriented" training toward "sustainability-centered" structural design thinking. Contemporary pedagogical approaches now emphasize the implicit integration of environmental principles within course curricula, incorporating strategies such as modular cutting, zero-waste pattern making, detachable construction systems, and functional reconstruction methodologies. This evolution represents an inevitable trend in Chinese fashion education reform, guiding students toward developing sustainable creative design solutions grounded in structural logic and ecological consciousness. Exemplary teaching modules introduce the structural philosophies and design methodologies of pioneering sustainable designers such as Issey Miyake and Stella McCartney. Through cross-case structural deconstruction and simulation-based reconstruction experiments, students achieve deepened cognitive understanding and practical application of sustainability strategies within digitalized educational contexts. In fashion education, garment structure design is not only about drafting rules and sewing process but also about structural logic and the ability to transfer ideas from the mind into a creative shape. With the application of 3D virtual simulation technology in teaching, a clear and dynamic mapping relationship between structure, form and creativity is established. By comparing and analyzing isomorphic features of structure treatment like pleat control, seam transfer and dart manipulation, parallel thinking and combinatorial creativity are cultivated. Both technical ability and value-oriented design awareness are required in the digital age. This is a new attempt to redefine professional competence in sustainable fashion.

6 Conclusion

In accordance with the results obtained by CiteSpace visualization software, this study takes the academic literature published at home and abroad from 2010 to 2025 as the research object and traces the research track, thematic focus and practical issues of applying 3D digital virtual simulation technology into garment construction courses in detail. Based on the clustering of keywords and the timeline visualization of 849 academic papers, it is found that the application of 3D virtual simulation in fashion design education has undergone a process of evolution from “technical tool use” to

“pedagogical model reconstruction”, and the overall research concern has gradually shifted from software application and operational efficiency to the reconstruction of curriculum content and student competencies. Subsequently, with the arrival of the digital – intelligent era, the demand for interdisciplinary talents skilled in digital design and intelligent manufacturing will gradually increase, and the educational value of 3D virtual simulation cannot be limited to improving operational efficiency from the dimension of efficiency, should be reconceptualized as an intelligent learning environment that deepens students’ structural cognition while fostering creative and analytical thinking. Many researchers have proved that teaching reform based on virtual simulation can promote the transformation from “skill-oriented” to “cognition-driven” teaching goals, and further promote the integration of teaching content and industrial practice. In the future, research should continue to investigate the application of virtual simulation across several key dimensions, including garment structural logic, design thinking development, sustainability-oriented strategies, and industrial collaboration. By integrating these perspectives, educators and researchers can establish digital, intelligent, and context-based teaching models for garment structure courses. These innovative frameworks will form a solid foundation for the high-quality development of fashion education in the digital era.

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About the Author

Yupei Cao, male, originally from Nanyang, Henan, China, Han ethnicity, currently affiliated with Shenzhen Polytechnic University. master's degree, fashion design and digital fashion.

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