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Research on Teaching Reform and Talent Development Pathways for Garment Construction Courses in Vocational Colleges Driven by 3D Virtual Simulation from a Constructivist Perspective

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Abstract: ***With the rapid advancement of digital technologies in the global fashion industry, vocational education is undergoing a profound transformation from traditional skill-oriented models toward innovation- and digital-competency-integrated paradigms. Addressing the prevalent challenges faced by Garment Construction courses in vocational colleges during their digital transformation, including the absence of authentic industry contexts, the disconnect between structural logic and creative thinking, and insufficient integration between digital tools and knowledge systems, this study adopts constructivist learning theory as its theoretical foundation and employs 3D virtual simulation technology to develop an integrated spiral teaching model that encompasses "foundational knowledge—operational skills—creative expression—reflective transfer." The research integrates digital interactive technologies including Virtual Reality (VR), Augmented Reality (AR), and 3D digital twins to design multi-tiered contextual learning tasks, systematically reconstructing the course's objective framework, content architecture, instructional processes, and assessment mechanisms. Additionally, it conducts an in-depth analysis of the correspondence between course modules and competency requirements for positions related to garment construction. The findings demonstrate that the constructivist teaching model driven by 3D virtual simulation significantly enhances students' cognitive depth in understanding garment structural logic and technological processes, while effectively promoting the transfer and development of digital thinking and innovative capabilities. This approach establishes a new talent cultivation mechanism in vocational education characterized by "virtual-real integration, task-driven learning, and reflective generation." This study provides practical reform pathways and theoretical paradigms for curriculum system reconstruction and pedagogical innovation in fashion design programs at vocational colleges in the digital-intelligent era.***

Keywords: Constructivist learning theory, 3D virtual simulation, Vocational education, Garment construction, Digital teaching reform, Curriculum system reconstruction.

1. Introduction

Against the backdrop of rapidly evolving digital-intelligent integration, the fashion industry is undergoing a profound transformation from "experience-driven traditional design and manufacturing models" toward" ecosystem-based collaborative systems characterized by data empowerment and intelligent responsiveness" [1]. The widespread adoption of digital-intelligent technologies—particularly digital fashion visualization, AI-assisted design, virtual simulation pattern making, and NFT fashion show releases—has continuously generated industry demand for digital fashion design professionals equipped with tri-dimensional collaborative capabilities spanning technology, design, and systems. Within the context of the fashion industry's digital transformation, digital-intelligent development has become a key strategic direction for the modernization of vocational education. The United Nations Educational, Scientific and Cultural Organization (UNESCO), in its Strategy for Technical and Vocational Education and Training (2022–2029) [2], emphasizes that the core mission of future vocational education lies in cultivating applied talents capable of adapting to the digital economy and broader societal transformation. Similarly, China has explicitly outlined in the Vocational Education Law (2022 Revision) and the National Vocational Education Reform Implementation Plan (the "20 Measures for Vocational Education") [3] the imperative to advance vocational education through "digital empowerment, industry-education integration, and collaborative innovation in intelligent manufacturing," with the aim of building a new vocational education ecosystem.

Currently, while digital teaching reform in fashion design programs at vocational institutions has achieved initial progress in hardware infrastructure and software systems, it remains largely at the stage of surface-level digital application [8]. A comprehensive review of existing pedagogical research reveals that systematic integration of constructivist learning theory with fashion technology courses remains notably insufficient in China. Most studies are confined to fragmented classroom case applications or experience-based improvements at the operational level, lacking systematic articulation of holistic curriculum restructuring and innovation capability generation logic within virtual simulation-based learning environments [9].

Taking the Garment Construction course in vocational institutions as the research object, this study adopts a constructivist learning perspective and focuses on three core research questions. First, under the conditions of industrial digital-intelligent transformation, how can systematic alignment be achieved between existing Garment Construction course content and the competency requirements of relevant occupational positions? Second, how can digital technologies such as 3D virtual simulation, guided by constructivist theory, empower the cultivation of innovative thinking in garment structural design and be transformed into instructional environment elements that support structural cognition, skill internalization, and creative generation? Third, centered on the integrated competencies of "structure—technology—design—digitality," how can a spiral and progressive reform pathway for garment technology course instruction be constructed?

2. Research Status of the Application of Constructivist Concepts in Curriculum Teaching Reform in Higher Education

Research on instructional design and pedagogical model innovation grounded in constructivist cognition and learning theory has gradually gained momentum both domestically and internationally. While studies applying constructivist learning theory to fashion design education remain virtually nonexistent in China, substantial progress has been achieved in other disciplinary fields. Based on a quantitative analysis conducted with CiteSpace software on 1,167 constructivist teaching-related publications indexed in CNKI from 2000 to 2025, a keyword timeline map was generated (Figure 1). The analysis reveals distinct shifts in research focus across different periods: During the emergent phase (2000–2010), research primarily centered on learner-centered autonomous knowledge construction models, emphasizing students' active exploration and meaning-making in authentic learning contexts [10]. In the stable development phase (2011–2020), keywords such as "situational design" and "innovative learning methods" began appearing with greater frequency. Researchers increasingly focused on constructing contextualized and scaffolded learning environments, promoting knowledge internalization and competence transfer through problem-driven, task-oriented, and scaffold - supported instructional strategies [12]. In the mature diffusion phase (2021–2025), alongside the emergence of new technologies and pedagogical paradigms, research attention shifted toward innovative applications in digital and virtual learning environments, integrating new media such as VR, AR, and online interactive platforms into constructivist learning to strengthen immersive experiences and dynamic feedback mechanisms [13]. Overall, current research on the application of constructivism in higher education curriculum reform demonstrates a comprehensive transition from traditional classrooms to technology-integrated environments, from knowledge acquisition to competence construction, and from individual learning to collaborative social learning. This trajectory provides crucial theoretical support and practical pathways for pedagogical innovation in vocational education.

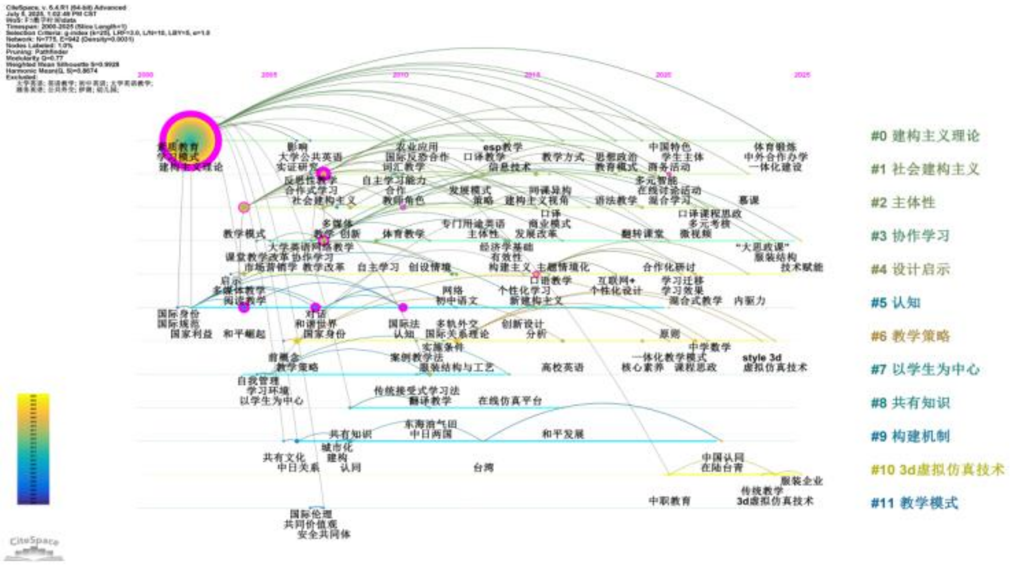

Figure 1: Timeline of Keywords in the Literature on the Application of Constructivist Teaching

3. Teaching Problems and Challenges in Garment Construction Courses at Vocational Institutions

Within talent cultivation systems at vocational institutions specializing in fashion design, Garment Construction courses have long been regarded as core technical modules. Their primary objective is to equip students with foundational competencies in pattern making, garment construction, and production process management. The proportion of instructional hours devoted to garment technology courses has historically served as a key indicator distinguishing vocational fashion education from general undergraduate programs. Some domestic vocational fashion institutions have attempted to strengthen students' technical abilities by simply increasing instructional hours for related courses. However, this traditional approach of content accumulation has proven insufficient for enabling students to acquire skills aligned with rapidly evolving occupational demands [14]. With the deepening of industrial digitalization and intelligent manufacturing, the contradiction between the traditional skill-training-centered teaching model and the competency requirements of emerging industry positions has become increasingly evident [15].

Specifically, current teaching of Garment Construction courses faces the following four major challenges:

First, teaching content lags behind industrial technological iteration. Traditional Garment Construction curricula focus largely on manual pattern making, basic sewing, and standardized process workflows, while the industry has widely adopted intelligent technologies such as fully automated modular production, 3D virtual pattern making, digital fabric simulation, and automated cutting systems [15]. International fashion brands have already introduced hybrid digital roles characterized by the integration of structure and design, such as Expert 3D Apparel Designers and Digital

Fitting Specialists. A significant technological gap exists between what students learn and the digitalized processes actually used in enterprises, resulting in extended retraining periods after graduation.

Second, competence cultivation remains overly narrow and insufficient to support innovative design demands. Current garment technology instruction often treats structure and process as isolated technical skills, lacking integration with design creativity, market trends, and sustainability concepts. As a crucial bridging component in fashion education, garment technology courses have long been regarded by institutions as foundational required skills for fashion students—reflecting the industry consensus that "designers must understand the principles of garment structure and construction to design effectively." However, existing pedagogical research pays insufficient attention to effective linkages between technical course content and design innovation. Course content is frequently criticized as monotonous and lacking fashion relevance, restricting students' development toward design-technology hybrid professional roles [16].

Third, teaching methods remain imitation-oriented, constraining the development of systematic thinking. Classroom instruction commonly follows a linear sequence of "teacher demonstration → student imitation → final product evaluation." [17] Students remain in passive execution roles, with limited opportunities for in-depth exploration of structural principles or autonomous decision-making in process design. This "knowing how without knowing why" model leads to inadequate analytical, adaptive, and problem-solving abilities when students encounter non-standard styles or real-world design projects.

Fourth, assessment systems prioritize outcomes over processes and show weak alignment with industry needs. Evaluation criteria typically emphasize final product completion and technical precision while overlooking students' cognitive processes in structural reasoning, process analysis and design, cost awareness, and digital tool application [15]. This outcome-biased assessment orientation diverges from industry expectations for comprehensive, multi-dimensional competencies, making it difficult for graduates to quickly adapt to enterprise environments that prioritize efficiency, collaboration, and innovation.

4. Constructing Teaching Pathways and Reconfiguring Modular Teaching Strategies for Garment Construction Courses Driven by 3D Virtual Simulation Systems from a Constructivist Perspective

As a major paradigm shift in educational thought since the twentieth century, constructivist learning theory emphasizes that knowledge is not an objective entity transmitted unidirectionally by teachers, but rather a meaning system actively constructed by learners through interaction with their environment, tasks, and others within specific contexts [4][5]. The core constructivist proposition holds that "learning does not arise from external transmission, but is dynamically generated through the interaction between individual experience and social context." [10] This epistemological shift requires instructional design to move away from curricula centered on the logical sequencing of disciplinary knowledge content and instead focus on learners' cognitive development stages, problem-solving processes, and mechanisms of social interaction [6].

From an epistemological perspective, constructivism posits that knowledge possesses three essential attributes: situatedness, experientiality, and sociality. Knowledge is regarded as "knowledge-in-action"—continuously generated and refined through perception, experience, and reflection within authentic or simulated tasks (Dewey, 1938) [16]. In the context of Garment Construction courses, this implies that students' understanding of garment pattern structures, sewing logic, and material properties should emerge from active engagement in design tasks, pattern-making operations, and problem-solving processes, rather than from passive memorization of standardized answers provided by instructors. Through constructivist processes of "learning by doing" and "learning through reflection on errors," students' knowledge systems become internalized and transferable across diverse experiential contexts.

From a curricular perspective, constructivism advocates for courses characterized by contextual orientation, process construction, and multi-dimensional interaction. Contextual orientation requires curricula to be grounded in authentic or simulated professional application scenarios. Clothing technology courses have long been criticized for lacking realistic contexts for the application of knowledge and skills. With the integration of 3D virtual simulation technology into garment technology education, instructional spaces expand from single physical training workshops into dynamic learning environments that integrate virtual and physical realities. This enables students to experience industrial workflows, comprehend process logic, and reflect on garment structure design within multidimensional environments such as virtual factories, intelligent cutting systems, and virtual modeling platforms.

Within a constructivist framework, the process-constructive nature of learning signifies that knowledge is dynamically generated through contextual experience and practical interaction. "Process construction" means that the core value of a course lies not in the complete presentation of outcome-based knowledge, but in students' ability to construct understanding dynamically through problem-solving, exploratory pathways, and iterative reasoning [15]. Specifically, Garment Construction courses must shift from a "results-oriented" approach to a "process-driven" model, where instructional design emphasizes generative tasks that create integrated pathways connecting knowledge, skills, and values.

Finally, regarding multi-dimensional interaction, the curriculum incorporates authentic enterprise-based garment structure and process cases and production workflows, constructing within metaverse-enabled environments a "school-enterprise collaboration, virtual-real integration, and co-creation/co-evaluation" instructional ecosystem. This approach promotes the multidimensional integration of technical competence, design innovation, and industrial understanding essential to contemporary vocational education (Figure 2).

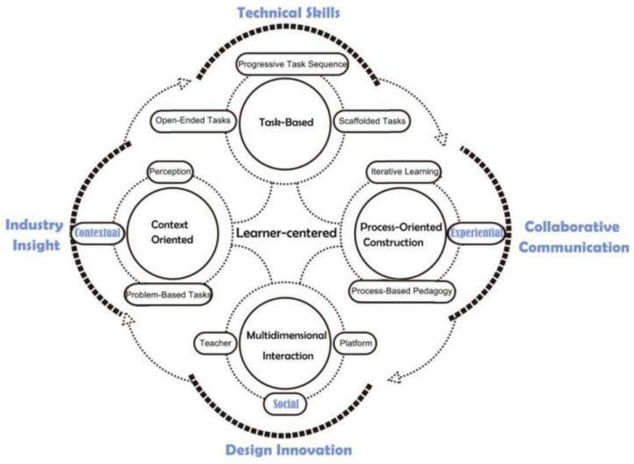

Figure 2: Learner-Centered Constructivist Teaching Framework

4.1 A Four-Level Spiral Teaching Model and Practical Pathways for Garment Construction Courses in Vocational Colleges from a Constructivist Perspective

From a constructivist perspective, the reform of Garment Construction courses in vocational colleges is organized around the internal logic of students' cognitive development, with instructional emphasis placed on "meaning-making" rather than "knowledge transmission." Within the constructivist curriculum framework, Garment Construction courses are no longer regarded as a linear accumulation of fragmented technical skills, but rather as an integrated system designed to facilitate learners' cognitive construction and competence development. Jerome Bruner (1966) [7], the renowned American cognitive psychologist, proposed the theory of the spiral curriculum, arguing that instruction should begin with learners' existing experiences and progressively deepen understanding through continuous exploration, reflection, and reconstruction.

Inspired by this theory, the present study proposes a four-level spiral progressive teaching model comprising "foundational knowledge → operational skills → creative expression → reflective transfer." This model aims to achieve dynamic generation of learners' cognitive systems and competence transfer through iterative cycles of knowledge deepening. As illustrated in Figure 3, the first level of this teaching model focuses on the formation of conceptual schemas and structural principles, establishing a cognitive foundation for subsequent skill transformation. The second level emphasizes operational practice within authentic or simulated tasks, where scaffolded progression enables the internalization of competencies from "being able to do" to "being able to analyze" and "being able to transfer." The third level positions the coupling of structure, process, and design as the innovation driver, facilitating a leap from technical proficiency to creative design. The fourth level employs peer assessment, reverse diagnosis, and cross-contextual reapplication to review, reconstruct, and extrapolate prior learning outcomes, feeding them back into new cycles of knowledge construction and forming a sustainable cognitive growth loop in garment structure understanding.

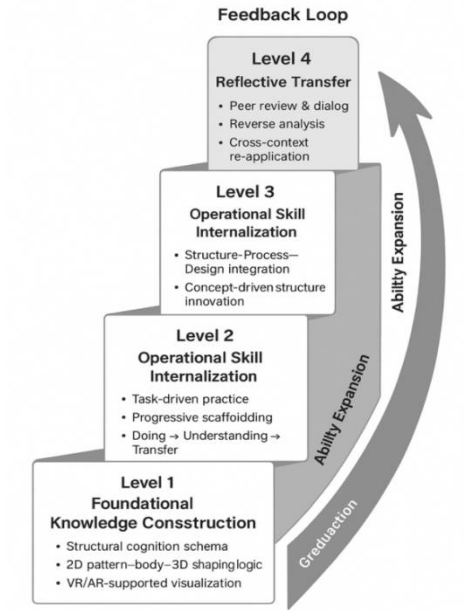

Figure 3: A Four-Level Spiral Progressive Teaching Model for Garment Construction Courses from a Constructivist Perspective

In terms of instructional design, this new constructivist-oriented teaching model is guided by four core principles: "contextual authenticity—task generativity — interactive collaboration—closed-loop evaluation." The course framework is structured around industrial workflows and occupational requirements, leveraging integrated systems of 3D virtual simulation, digital pattern-making, and virtual-physical convergence to create highly authentic learning environments. Learning tasks are organized through problem chains and project-based structures, with optimized scaffolding strategies and data-informed learning tracking. Process-oriented assessment cycles of "do—reflect—evaluate—revise" replace one-off outcome evaluations, ensuring dynamic generation and continuous optimization of learners' cognitive structures [19].

Course objectives are articulated across four main dimensions: 1) Knowledge objectives — to master structural concepts and process principles and form stable cognitive schemas; 2) Skill objectives — to achieve transferable operations in pattern-making, structural adjustment, and process integration within task-based contexts; 3) Creative objectives — to realize integrated innovation in form and process strategies with structural innovation at the core; 4) Transfer objectives — to accomplish reflective reconstruction and experiential extrapolation across different materials, pattern types, and application contexts.

4.1.1 Foundational Knowledge Construction: A Mechanism for Generating Structural Cognitive Schemas Supported by 3D Virtual Reality

Traditionally, foundational garment structure instruction has focused on memorizing pattern-making procedures and technical terminology. Theoretical knowledge has been delivered in fragmented and linear fashion, making it difficult to support early-stage cross-representational understanding. From a constructivist learning perspective, the instructional approach to foundational garment construction knowledge should shift from "transmitting isolated knowledge points" to "constructing conceptual frameworks," enabling students to establish early in their learning an integrated cross-representational cognitive schema linking pattern elements, body proportions, three-dimensional form generation, and construction pathways. To this end, 3D virtual simulation is introduced to transform abstract planar-spatial relationships—previously dependent on imagination and 2D pattern inference—into visible, interactive, and verifiable learning media [20].

Taking the "Fundamentals of Garment Construction" golden course at Shenzhen Polytechnic University's Fashion Design program as an example, this study examines how foundational structural knowledge instruction can be restructured under the guidance of constructivist learning theory through VR virtual simulation technologies. Practical research reveals that constructivist learning principles and design thinking both exhibit nonlinear "divergence–convergence" cognitive trajectories, sharing similar cyclical logic in their knowledge generation mechanisms. Based on this conceptual alignment, the study adapts the Double Diamond process structure from design thinking to curriculum design, developing a "Double-Diamond Constructivist Model for Cross-Representational Learning" (Figure 4).

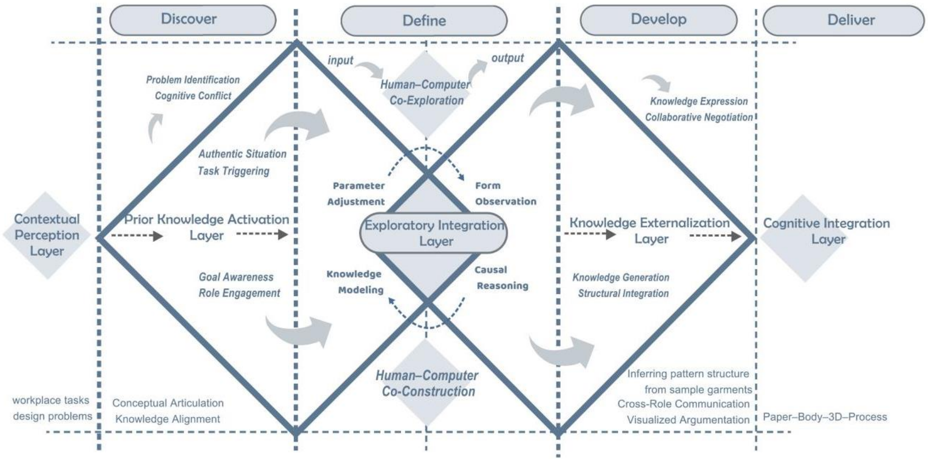

Figure 4: Double-Diamond Constructivist Teaching Model for Cross-Representational Learning in Garment Construction Courses

Table 1: Core Scenario-Based Instructional Design for the "Foundational Knowledge Construction" Phase under a Constructivist Framework

Core Teaching Components Authentic Workplace Scenarios	Scenario A: Designer–Pattern Maker Communication and Sketch Alignment	Scenario B: Cross-Functional Review (Evaluation of apparel Structural and Process Feasibility)	Scenario C: Fabric Change (Sample Review and Same-Style/Different-Fabric Design Extension)
1. Authentic Context Anchors	Designers translate design sketches into detailed structural specifications and communicate them to pattern makers, converting garment details into data-driven structural and process annotations.	During design review meetings, designers explain the structural logic of the proposed design to the technical department and collaboratively evaluate its process feasibility with pattern makers and process engineers.	During the product sampling stage in apparel brand enterprises, designers evaluate pattern adaptability and process compatibility for the same style produced in different fabrics.
2. Preconception Activation and Review	① Functions of structural elements such as bust darts, sleeve-cap ease, and balance marks; ② Correspondence between basic block patterns and garment silhouettes; ③ Common misconceptions regarding fit–ease–silhouette relationships.	① Principles of garment body structural design; ② Correspondence between pattern construction and garment manufacturing processes; ③ Application and design of seam allowances and seam types.	① Review of the relationship between fabric physical properties and structural elements; ② Comparative analysis of sample garments to examine differences in shape retention, style compatibility, and pressing feasibility across fabrics.
3. Inquiry Tasks	① Single-variable exploration: adjust only one structural parameter and observe changes in 2D patterns and 3D garment appearance; ② Multi-variable coupling: combine dart transfer and ease adjustment to explore the balance between silhouette and fit.	Formulate testable hypotheses (e.g., whether structural adjustments influence sewing sequence or defect rate); Use 2D/3D linkage and process-overlay functions to observe how changes in structural lines affect process pathways and propose optimization strategies.	Formulate hypotheses such as whether variations in fabric thickness or fiber composition affect fit and process sequence; ① Single-variable exploration: maintain the same style while switching fabrics and record shape deformation and overall visual effects; ② Multi-variable exploration: adjust dart positions after fabric changes to examine compatibility between pattern structure and fabric characteristics.
4. VR and Digital Technology Support	Use VR, AR, and AI technologies to cross-compare design sketches with virtual garment forms, including the virtual alignment of mid-waist designs, A-line versus H-line silhouettes, and their corresponding pattern structures.	Synchronized 2D/3D visualization windows and parameter sliders; Error visualization through planar–spatial comparison of wrinkling and tension effects; Three-dimensional visualization of structural parameter changes.	Use Style3D Fabric software to simulate fabric texture variations and combine them with virtual garment models to enable rapid 3D material switching for accelerated perceptual understanding.
5. Learning Outputs and Outcomes	Mastery of the triadic conceptual relationship among industry terminology, structural relationships, and validation processes.	Development of integrated judgment and optimization capabilities across design, structure, and process.	Formation of a dynamic cognitive model for material–structure–process adaptive coordination.

In the initial phase of the course, instruction is implemented through contextualized introductions and prior-concept activation, with core problems derived from authentic professional scenarios such as “pattern maker communication and design sketch matching,” “cross-functional collaborative review,” and “same style, different fabric” applications encountered by fashion designers. As shown in Table 1, Scenario A requires that “designers must compile structural design specifications based on design sketches and communicate these to pattern makers, providing detailed data-driven structural and construction annotations for specific design elements.” Within this context, instructors activate students’ prior conceptions of garment construction fundamentals using authentic situational anchors and guide problem definition and hypothesis generation through inquiry-oriented keywords such as “planar pattern–silhouette correspondence, parameter adjustment, and pattern mapping transformation.”

During the “inquiry task” phase, students engage in constructive self-directed learning within a 3D virtual simulation platform, progressing from problem exploration to structural verification. Leveraging integrated key technologies including AR, VR, and 3D virtual modeling, students conduct single-variable and multi-variable virtual experiments around core structural parameters (such as dart intake, grain direction, and ease design), observing spatial transformation relationships between 2D patterns and 3D garments while experiencing fit through virtual try-on systems. Throughout this process, instructors provide real-time technical scaffolding through “Human–Computer Co-Exploration,” helping students identify the interconnected effects of parameter changes and causal relationships in silhouette variations, gradually facilitating a shift from experiential judgment to structural-logical reasoning.

This approach, which starts from the occupational requirements of fashion designers and matches foundational theoretical knowledge points in the curriculum with real workplace application scenarios, stimulates vocational resonance among students during the learning process. In the classroom, students not only apply structural knowledge to multi-dimensional problem analysis and virtual verification, developing “data-driven–visualized–logical” structural thinking capabilities, but also achieve knowledge transfer and creative expression within authentic occupational contexts, transforming theoretical knowledge into practical competencies for design decision-making and construction optimization, ultimately forming an integrated “structure–silhouette–construction” knowledge-cognitive model.

4.1.2 Internalization of Operational Skills: A Task-Driven and Progressively Scaffolded Pathway for Skill Transformation

Pattern-making and garment construction skills training constitutes the core of fashion technology instruction at vocational institutions. Through repeated imitation and practice of basic pattern-drafting procedures, students gradually learn to manipulate pattern lines flexibly and ultimately acquire the ability to design flat garment patterns with aesthetic sensibility. However, few students with design backgrounds are able to internalize garment construction skills as a source of design-driven innovation. Under a constructivist framework, the instructional design of this module adopts task-driven learning and progressive scaffolding as its primary pathways, aiming to transform the garment construction knowledge built in the previous stage into a transferable system of operational competencies.

Grounded in Vygotsky’s Zone of Proximal Development (ZPD) theory and principles of situated learning, course tasks are organized into a three-tier progressive structure according to skill complexity and cognitive load: foundational operational tasks, problem-diagnosis tasks, and innovative integration tasks [21].

At the introductory level, instructors employ procedural scaffolds, such as exemplar demonstrations and step-by-step operational templates, to help students master standardized workflows for pattern drafting and sewing [22]. At the intermediate level, conceptual scaffolds guide students to identify structural deviations and construction errors within virtual simulation environments, enabling them to understand the logical chain linking “structure — silhouette — construction.” At the advanced level, strategic scaffolds are implemented through gradual withdrawal of instructor guidance, encouraging students to independently plan structural design schemes and construction pathways for open-ended garment style cases, and to validate and express their solutions through 3D virtual modeling and AI-assisted tools.

As scaffolding is progressively removed, learners move through a spiral progression of “imitation — understanding — innovation,” achieving a competency transformation from operational execution to structural comprehension and finally to creative transfer. This process gradually forms a skill internalization pathway centered on “being able to do—being able to analyze—being able to transfer.” This teaching model not only achieves bidirectional construction of knowledge and skills, but also equips learners—supported by virtual simulation technologies—with professional capabilities to translate structural logic into practical design and production decisions.

4.1.3 Generation of Creative Expression: Integration and Innovative Practice of Structure–Construction–Design Logic

Students in vocational fashion design programs generally demonstrate insufficient awareness in structural innovation design, particularly in professional contexts, where their structural creative abilities are often evaluated by fashion enterprises as relatively weak. This problem stems fundamentally from the absence of cross-curricular instructional design targeting the “creative expression generation” stage within existing fashion technology curricula [22]. Current teaching practices remain predominantly oriented toward technical skills training or classroom-based imitation of standard garment structures. This fragmentation — where garment construction instruction becomes overly technical and design education overly formalized—prevents fashion design students from establishing cognitive connections between structural thinking and creative design.

The primary objective of this stage is to strengthen students’ recognition that structural creative thinking originates from

Table 2: Correspondence Between Fashion Design Concepts and Structural Design Features

Design Concept	Corresponding Structural Design Features	Contemporary Designers and Representative Works
Structuralism	Three-dimensional geometric structures (e.g., square and triangular forms); creative structural line design; integration of geometric structures into fitted silhouettes	Comme des Garçons — geometric structural experimentation; Jun Takahashi — reversible fashion and inside-out garment concepts
Zero-Waste Design	Integrated structural design (e.g., seamless construction, maximal material utilization)	Timo Rissanen — seamless construction and precision cutting to reduce waste; Issey Miyake — emphasis on maximal use of fabric and structural efficiency
Deconstruction	Asymmetry; reverse seaming; disruptive cutting and structural recomposition	Yohji Yamamoto — asymmetry and reverse construction; Martin Margiela — irregular joining and destructive cutting
Feminist Style	Square shoulders; T-shaped silhouettes; linear forms emphasizing strength; cinched-waist androgynous structures	Ann Demeulemeester — linear silhouettes, strong shoulders, and neutral waistlines; Vivienne Westwood — subversive structural reinterpretation of corsetry in the 1990s
Minimalism	Minimal segmentation; strong silhouette integrity	Jil Sander — minimalist structural design emphasizing holistic silhouette continuity

design conceptual reflection, and to cultivate their ability to grasp the correspondence between design concepts and structural expression. In course design, Design Concepts are first integrated as the central axis of the structural expansion and innovation teaching module. Diverse contemporary fashion movements—including Zero-Waste Design, Structuralism and Deconstructivism, and Feminist Fashion — are introduced alongside masterwork case studies that reverse-engineer how designers employ corresponding structural approaches to articulate design philosophies. This enables students to critically reorganize and redefine the relationship between design concepts and their corresponding garment construction pattern details (as shown in Table 2). This conceptual intervention not only deepens students' understanding of "structure," but also helps them recognize during the learning process that garment construction itself constitutes a "Design Language"—a medium for expressing formal logic and cultural positions.

During the 3D virtual reality garment construction experimentation stage, students enhance their perception of structural design innovation through experiential interactive learning and embodied cognition. Within virtual reality training systems, instructors employ interconnected technologies—including VR and AR interfaces, virtual fitting and garment-switching devices, and 3D garment modeling software—to guide students through interactive exercises involving structural transformation of common garment construction elements such as cut-outs, layering, segmentation, and pleating. This enables learners to intuitively grasp the intrinsic coupling relationships between different categories of garment silhouette languages and pattern-making logic. For example, in a creative women's top design case inspired by deconstructivist aesthetics, students use 3D virtual garment modeling software to substitute and rearrange garment pattern pieces, enabling them to understand the underlying structural principles governing dart dispersion and pleat-based design innovation. By simulating similar styles with different structural details using various fabrics and validating results through virtual face-mapped try-on displays, students can empirically verify how variations in fabric properties and structural design language lead to changes in garment style. Through this learning process, students gradually transition from being imitators of structure to active creators of structure, forming a cognitive model of structure-driven design [24]. This model enables them to independently assess the rationality of structural design innovation and understand the logic of variable structural innovation expansion in design series within future complex comprehensive fashion design learning. It fundamentally breaks away from traditional garment technology teaching models, providing both theoretical foundation and practical pathways for vocational fashion design education, driving the transformation of construction instruction from operational skill training toward innovative cognitive construction (Figure 5).

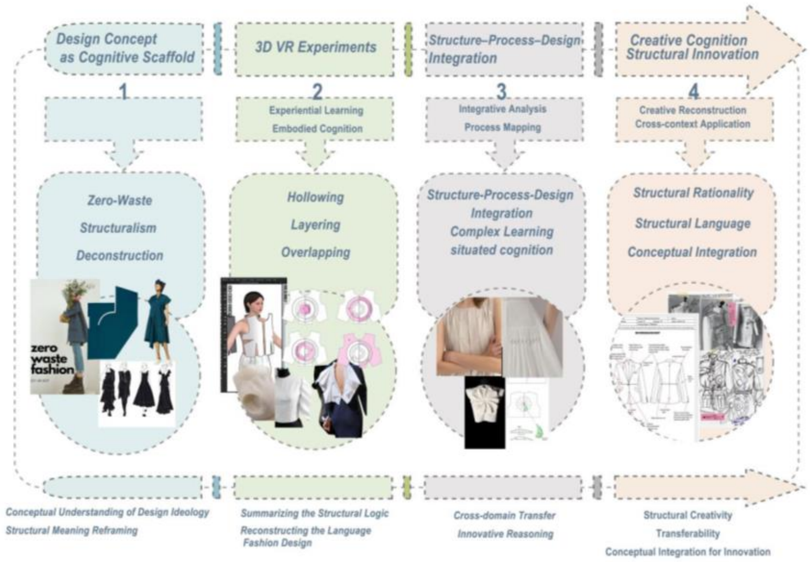

Figure 5: A Four-Stage Constructivist Learning Pathway Model for Garment Construction Innovation

4.1.4 Reflective Transfer and Extension: Constructing a Teaching Closed Loop and Learning Tracking within a Virtual–Physical Integrated Environment

Innovation in garment construction manifests through the interrelated structural configurations of different garment components, where transformations of structural or construction elements from other garments can often be identified within a single fashion piece. For fashion designers, mastering the core application techniques of garment construction design fundamentally depends on the ability to reflect upon, transfer, and analogically extend structural solutions across similar design cases [15]. Within the four-level spiral teaching model, the reflective transfer module aims to encourage students to abstract their existing structural knowledge, design experience, and cognitive outcomes from original contexts and to reapply and recreate them within new design tasks.

To achieve this pedagogical objective, the course establishes a cyclical training system composed of "reverse analysis — structural decomposition — pattern reconstruction — contextual reapplication" (Figure 6). First, instructors reference the task formats used in the WorldSkills China Fashion Technology Competition to arrange randomized design assignments where students draw lots to determine their new garment design tasks. These lottery elements include keywords such as "four-panel bodice," "one-piece standing collar," "set-in sleeve," "symmetrical," "asymmetrical," and "gathered." Each student freely combines 3-4 selected elements to create a new design. Under instructor guidance, students then conduct reverse silhouette analysis of their completed designs, deconstructing finished garment forms from top to bottom into articulable and conceptualized sets of garment component structural elements and pattern logic. This process aims to break away from experience-based mechanical copying and cultivate students' awareness that every design outcome is governed by an underlying set of decomposable and reconstructable garment construction "grammar." [17]

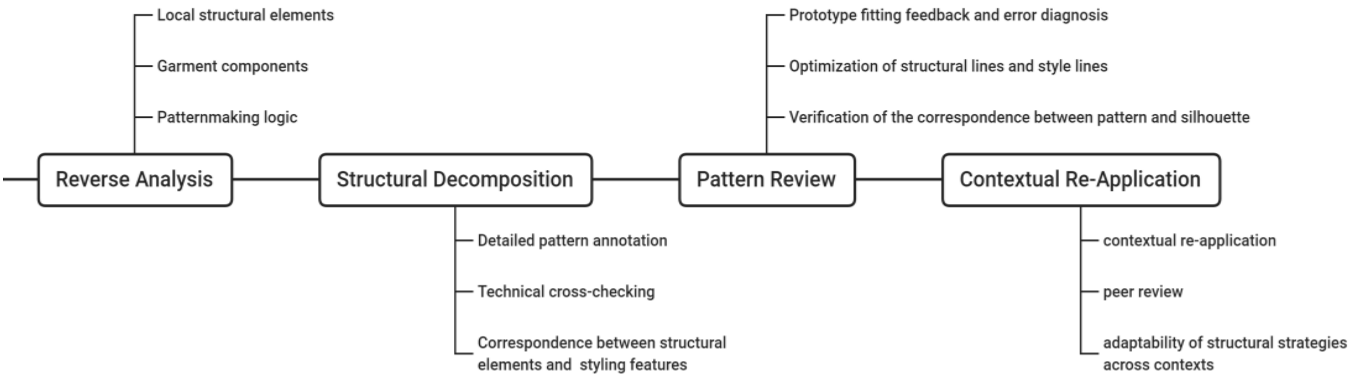

Figure 6: Cyclical Training Framework for Reflective Transfer in Garment Structure Learning

During the structural decomposition and pattern reconstruction stages, students systematically compare the extracted component elements with previously learned pattern template and localized structural knowledge, conducting technical cross-referencing and annotation. They perform "retrospective" combinatorial practice with original structural details, ultimately completing pattern layouts through recalculation. Upon entering the contextual reapplication phase, students work in pairs for peer evaluation, with each pair exchanging one design option tag to create a new task scenario. Through this reapplication training of "changing the task without changing the logic" and "changing the context without changing the method," students are compelled to test the transferability and adaptability of their existing structural knowledge in new problem contexts, thereby advancing from "mastering individual styles" to "mastering structural methodology."

Consequently, the constructivist-inspired four-level spiral instructional design—"foundational knowledge—operational skills—creative expression—reflective transfer"—breaks away from traditional unidirectional knowledge transmission logic, achieving organic integration from conceptual understanding to skill construction and from structural innovation to cross-contextual transfer, ultimately forming a comprehensive development system where knowledge, technology, and values mutually reinforce one another. This pedagogical model provides both theoretical foundation and practical pathways for reforming garment construction courses, while also offering a replicable framework for exploring digitally integrated and sustainability-oriented vocational fashion education.

5. Conclusion and Future Prospects

Situated within the context of industrial transformation in the digital-intelligent era, this study takes garment construction courses at vocational institutions as its entry point. Working within a constructivist learning theory framework and incorporating digital technologies such as 3D virtual simulation, it attempts to build a four-level spiral teaching structure centered on "foundational knowledge—operational skills—creative expression—reflective transfer," and accordingly reconstructs the course objective system, instructional scenario design, and learning evaluation pathways for fashion technology education.

Research findings demonstrate that transforming garment construction courses from mere "skill training grounds" into comprehensive competence-generation environments encompassing "structural cognition — construction decision-making — design innovation — cross-contextual transfer" not only helps address persistent problems in traditional fashion technology instruction—namely "outdated content, monotonous methods, and imbalanced assessment" — but also provides vocational institutions with curriculum reform approaches that align closely with front-line industry logic for talent cultivation in the digital-intelligent era [25].

Looking toward the future, constructivist-informed and 3D virtual simulation-driven reforms in garment construction education represent not merely updates to teaching technologies and methods, but a comprehensive reshaping of digital learning ecosystems. These ecosystems are supported by curriculum cluster coordination, industry–education integration mechanisms, and learning analytics technologies. Such reforms drive the transformation of talent cultivation models in vocational fashion design programs from singular skill training toward the development of multi-dimensional, high-level professional technical competence, achieving deep alignment with China’s national vocational education goals for cultivating “high-quality technical and skilled professionals.”

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