Textile & Leather Review

ISSN 2623-6281 | www.tlr-journal.com | 10.31881/TLR

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How to cite: Wen J, Yang C, Yang S, Hu C, Bungbua P. Research on the Association Between Digital Transformation and Teaching Model Change among Garment Engineering Educators: An Empirical Study Based on Structural Equation Modeling. Textile & Leather Review. 2026; 9:4993-5009. https://doi.org/10.31881/TLR.2026.4993

How to link: https://doi.org/10.31881/TLR.2026.4993

Published: 27 April 2026

Research on the Association Between Digital Transformation and Teaching Model Change among Garment Engineering Educators: An Empirical Study Based on Structural Equation Modeling

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Article

https://doi.org/10.31881/TLR.2026.4993

Published 27 April 2026

ABSTRACT

With the continued implementation of the education digitalization strategy, digital transformation has become a key driving force behind the paradigm shift in higher education teaching. This study focuses on apparel engineering educators at application-oriented undergraduate institutions in Jiangxi Province. Based on 447 valid questionnaire responses, it employs structural equation modeling to empirically analyze the pathways through which digital transformation is associated with changes in teaching models. The results reveal a significant positive association between digital transformation and teaching model reform. Among the four dimensions of digital transformation—perceived technological infrastructure, digital resource development, policy support, and digital management—perceived technological infrastructure shows the strongest direct association, followed by digital resource development and digital management, while policy support operates mainly indirectly. Regarding the three dimensions of teaching model change, teaching methods exhibit the strongest association with digital transformation (explaining 29.4% of the variance), followed by instructional design (26.7%) and assessment practices (22.6%). This study systematically maps the associational pathways from digital transformation to teaching model change, providing empirical evidence and practical implications for advancing digital transformation in application-oriented universities.

KEYWORDS

digital transformation, teaching model change, apparel engineering, application-oriented undergraduate institutions, structural equation modeling

INTRODUCTION

The rapid advancement of digital technologies is reshaping the global higher education ecosystem at an unprecedented pace. Amid this wave of transformation, the reconstruction of teaching models has emerged as a core issue in higher education reform. This is particularly urgent in interdisciplinary fields that emphasize the integration of professional knowledge systems and practical skills—such as apparel engineering education. Existing research shows that digital transformation not only changes the medium of knowledge dissemination but also redefines the interactive relationships among educational stakeholders. However, empirical studies investigating how digital technologies are associated with systematic changes in teaching models among apparel engineering educators—especially in application-oriented undergraduate institutions—remain scarce.

This study focuses on the pathways linking digital transformation to teaching model changes among apparel engineering educators in application-oriented universities . It constructs a four-dimensional analytical framework—“Technology–Policy–Management–Resources”—to examine how key elements (perceived digital infrastructure, policy support systems, digital management mechanisms, and digital educational resource development) interact to shape changes in three core teaching components: instructional design, teaching methods, and assessment practices..

By integrating the theory of technology diffusion and the perspective of educational ecology, this study employs multi-source data—including 447 valid teacher questionnaires, digital construction records from 12 institutions, and in-depth interviews with 8 academic leaders. For the first time, it reveals the complete associational chain of digital transformation in apparel engineering education at application-oriented undergraduate institutions: perceived technological infrastructure serves as the material foundation, institutionally secured by policy support; digital management enables optimal resource allocation, and resource development is directly associated with the reconstruction of core teaching elements. These findings expand the theoretical understanding of digital transformation in higher education and provides empirical evidence for application-oriented institutions to design differentiated digital education development strategies.

LITERATURE REVIEW

The Connotation and Characteristics of Digital Transformation

Digital transformation refers to the fundamental reshaping of organizational processes, culture, and user experience through digital technologies. In education, digital transformation goes beyond technological adoption—it signifies a comprehensive renewal of educational philosophies, teaching methods, and management models. Kocaoglu and Kirmizi developed a digital transformation maturity model [1], emphasizing that digital transformation is a complex systemic process involving technological infrastructure, digital resources, organizational management, and policy support. This viewpoint provides the theoretical foundation for our multidimensional measurement framework.

From the perspective of teaching model reform, digital transformation exhibits characteristics. At the technological level, integrated application of cloud computing, big data, artificial intelligence, and the Internet of Things redefined access to teaching resources, driving the teaching process toward greater intelligence and personalization [2]. At the organizational level, digital transformation requires supportive management systems and operational mechanisms, including digital teaching evaluation systems and mechanisms for cultivating teachers' digital literacy. At the cultural level, it demands that educators shift from traditional pedagogical mindsets to embrace new teaching philosophies-from knowledge transmitters to learning facilitators and resource designers. This triadic synergy(technology-enabled, organizationally supported, and culturally adapted) jointly drives the profound transformation of teaching models: from teacher-centered to student-centered, from knowledge transmission to competency cultivation, and from standardized teaching to personalized learning.

Theoretical Foundations of Teaching Model Change among Educators

A teaching model refers to a relatively stable framework of teaching activities guided by specific educational philosophies. Traditional teaching models are teacher-centered and emphasize one-way knowledge transmission. With the advancement of modern educational theories—such as constructivist, multiple intelligences theory, and collaborative learning—teaching models have gradually shifted toward a student-centered, competency -based approaches.

Sembey et al. found that in a digital environment [3], teaching models exhibit high interactivity, strong personalization, and enhanced resource sharing. The teacher's role expands to include designers, facilitators, and promoters of learning activities. This shift in role demands higher levels of digital literacy and teaching innovation from educators.

Digital transformation influences instructional design, teaching methods, and assessment strategies. In instructional design, educators reorganize content based on digital tools. In teaching methods, innovative approaches such as flipped classrooms, blended learning, and project-based learning are widely adopted. In assessment practices, data-driven formative evaluation and diversified methods are emerging trends.

The Particularities of Teaching in Apparel Engineering

Apparel engineering is a typical application-oriented discipline, characterized by a balanced of theory and practice,integration of art and technology, and fusion of traditional craftsmanship with digital techniques. These features present both unique opportunities and challenges.

From the perspective of opportunity, digital technologies offer rich tools： 3D design software (CLO 3D,Browzwear); virtual fitting systems and smart manufacturing technologies. Research by Casciani et al. shows that these technologies improve teaching efficiency and enhance students' learning experiences [4]. From the perspective of challenge, educators face rapid technological updates, high equipment costs, and fragmented resources. According to Rosca et al. digital transformation demands continuously update and master new technological tools [5], placing greater demands on professional development.

Current Status of Relevant Empirical Research

In recent years, empirical on digital transformation and teaching models have several limitations. First, they often lack discipline-specific depth. Second, methods are relatively simplistic, relying primarily on qualitative approaches or basic statistical. Third, most focus on developed regions or key universities, with insufficient attention to application-oriented undergraduate institutions.

Gumaelius et al. conducted case studies on the digital transformation of engineering education in Nordic countries [6], finding that digital transformation significantly altered teaching content and methods. However, the regional and cultural context differs greatly from China. Xu et al. analyzed the digital transformation of China's garment manufacturing industry [7], but their focus was at the industrial level, not within education. Among domestic studies, Gao et al. explored the effectiveness of multimodal teaching strategies in fashion programs at vocational colleges [8], but the research subjects were vocational institutions rather than under-graduate ones. Wang and Qv examined innovations in the teaching model of a "Fashion Marketing" course under the context of industry-education integration [9], but their research was limited to a single course.

Thus,, existing research provides valuable references but falls short in target population, methodological rigor, and analytical depth. This study aims to fill these gaps using large-sample empirical analysis to examine the specific associations between digital transformation and teaching models among apparel engineering educators at application-oriented undergraduate institutions.

RESEARCH DESIGN

Construction of the Theoretical Framework

Based on the literature, this study constructs a theoretical framework integrating the Technology Acceptance Model (TAM) ,Innovation Diffusion Theory (IDT),and educational informatization. Digital transformation is conceptualized across four dimensions: perceived technological infrastructure, digital resource development, policy support, and digital management. Teaching model change is broken down into three dimensions: instructional design, teaching methods, and assessment practices.

The framework posits that digital transformation is positively associated with innovation in instructional design, teaching methods, and evaluation through improved technological environment, enriching teaching resources, policy support, and optimizing management mechanisms.Teacher characteristics(education, professional title, teaching experience, gender) are included as control variables.

Research Hypotheses

H1: Digital transformation is positively associated with changes in teaching models, after controlling for individual teacher characteristics.

H2: Different dimensions of digital transformation show varying strengths of association with teaching model change.

H3: The association between digital transformation and teaching model change differs across teaching process components (instructional design, teaching methods, assessment).

RESEARCH METHODS

Research Subjects

This study targets apparel engineering educators at application-oriented undergraduate institutions in Jiangxi Province. Jiangxi was selected for three reasons: (1)it has a large number of such institutions, providing a representative sample; (2) it began promoting educational informatization relatively early; (3) the research team has an established fieldwork foundation.

Stratified sampling was adopted. First, institutions in Jiangxi offering apparel engineering programs were identified. Then,teachers were randomly sampled from each institution. The final sample included 10 institutions, such as Jiangxi Institute of Fashion Technology, Jiangxi University of Science and Technology, and Nanchang Institute of Technology.

Data Collection

Data were collected via a questionnaire survey. The questionnaire was based on validated instruments from domestic and international studies, adapted to the context of apparel engineering. Table 1 shows examples of how general items were adapted to reflect engineering-specific digital tools (e.g., CAD/CAM, 3D simulation).

Table 1. Examples of Questionnaire Item Adaptation for Apparel Engineering Context

Original General Item	Adapted Item	Adaptation Basis
"I can use digital tools to design teaching content."	"I can use CLO 3D or Browzwear to create digital garment prototypes for teaching demonstrations."	Industry-standard 3D design software
"The institution provides virtual simulation resources."	"The institution provides virtual fitting systems and digital sewing simulation platforms."	Apparel engineering lab requirements
"Digital assessment tools help me evaluate student work."	"I use learning analytics from digital pattern-making software to assess student progress."	Formative assessment in engineering design

Note: These examples are representative of the adaptations made; the full questionnaire is available from the corresponding author upon request.

The questionnaire consisted of three sections: Section 1: Basic information (e.g., gender, age, education, professional title, teaching experience); Section 2: Digital transformation scale, covering four dimensions—technological infrastructure, digital resource development, policy support, and digital management; Section 3: Teaching model reform scale, covering instructional design, teaching methods, and assessment. All items used a 5-point Likert scale.

A mixed-mode distribution strategy combining online (via Wenjuanxing platform) and offline (through site visits and postal distribution).Data collection took place from March to May 2024. A total of 450 questionnaires were distributed, with 447 valid responses returned—a 99.33% effective response rate. Among them, 286 were completed online, and 161 offline. Comparative analysis showed no significant differences across dimensions between the two modes, indicating no systematic bias.

Data Analysis Methods

Data were analyzed using SPSS 26.0 and AMOS 24.0. Descriptive statistics, internal consistency (Cronbach's), exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), Pearson correlations, multiple linear regression and structural equation modeling (SEM) were employed.Model fit was assessed using χ^2/df , GFI, RMSEA, CFI, NFI, TLI, and other indices. Mediation and moderation effects were tested using bootstrap methods.

RESEARCH FINDINGS

Sample Characteristics Analysis

Table 2 presents the socioeconomic characteristics of the 447 valid samples. Most teachers hold a master's degree (73.15%); 70.47% have junior or intermediate professional titles; 57.49% have 10 years or less of teaching experience; 68.23% are female. The sample is relatively young and highly educated, which may favor digital adoption.

Table 2. Analysis of Socioeconomic Characteristics of the Survey Sample

Variable	Category	Frequency	Percentage (%)
Education	Bachelor's	120	26.85
	Master's	327	73.15
Title	Junior/Intermediate	315	70.47
	Associate Senior and Above	132	29.53
Teaching Experience	≤10 years	257	57.49
	>10 years	190	42.51
Gender	Male	142	31.77
	Female	305	68.23

Scale Reliability and Validity

Reliability

The overall Cronbach's α value for the digital transformation scale is 0.928, sub-dimensions: technological infrastructure 0.875, digital resource development 0.855, policy support 0.890, and digital management 0.811.For the teaching model change scale,overall Cronbach's α is 0.925, sub-dimensions: instructional design 0.892, teaching methods 0.885, and teaching assessment 0.878. These also surpass the 0.8 threshold, demonstrating that the scales used in this study have high reliability.

Validity

Content validity was confirmed by five experts. Confirmatory factor analysis (CFA) showed all standardized factor loadings >0.6, average variance extracted (AVE) >0.5, composite reliability (CR) >0.7, indicating good convergent validity.

Table 3. Convergent Validity Test Results for the Digital Transformation Scale

Factor	Item	Standardized Loading	SMC	t-value	p-value	AVE	CR
Perceived Technological Infrastructure	Infrastructure 1	0.802	0.644	—	—	0.639	0.875
	Infrastructure 2	0.886	0.785	20.487	0		
	Infrastructure 3	0.85	0.723	19.739	0		
	Infrastructure 4	0.637	0.406	13.88	0		
Digital Resource Development	Resource 1	0.847	0.717	—	—	0.596	0.855
	Resource 2	0.722	0.521	16.189	0		
	Resource 3	0.743	0.551	16.768	0		
	Resource 4	0.772	0.597	17.58	0		
Policy Support	Policy 1	0.877	0.769	—	—	0.67	0.89
	Policy 2	0.832	0.692	21.779	0		
	Policy 3	0.729	0.531	17.838	0		
	Policy 4	0.829	0.688	21.685	0		
Digital Management	Management 1	0.791	0.626	—	—	0.592	0.811
	Management 2	0.857	0.735	14.71	0		
	Management 3	0.643	0.414	12.896	0		

Discriminant validity was confirmed as the square root of AVE for each construct exceeded its correlations with other constructs (see Table 4 for discriminant validity matrix).

Table 4. Discriminant Validity Test Results for the Digital Transformation Scale

Dimension	Technological Infrastructure	Digital Resource Development	Policy Support	Digital Management
Technological Infrastructure	**0.8**			
Digital Resource Development	0.257	**0.772**		
Policy Support	0.218	0.474	**0.819**	
Digital Management	0.144	0.294	0.259	**0.769**

Note: Diagonal values are the square roots of AVE; off-diagonal values are inter-construct correlations.

Model Fit Assessment

The SEM model showed acceptable fit ($\chi^2/\mathrm{df} = 3.598$) slightly above 3, acceptable.GFI = 0.922, RMSEA = 0.076,RMR = 0.061, CFI = 0.939, NFI = 0.918, NNFI = 0.924,TLI = 0.924,PGFI = 0.646, PNFI = 0.734, and PCFI = 0.751.While some indices are marginally below ideal thresholds, the overall fit is acceptable given sample size and model complexity. (See Table 5 for complete fit statistics.).

Table 5. Model Fit Statistics for the Digital Transformation Scale

Fit Index	Recommended Threshold	Observed Value	Evaluation
χ^2	–	302.221	–
df	–	84	–
p-value	> 0.05	0	–
χ^2/df	< 3	3.598	Acceptable
GFI	> 0.9	0.922	Good
RMSEA	< 0.08	0.076	Good
RMR	< 0.05	0.061	Acceptable
CFI	> 0.9	0.939	Good
NFI	> 0.9	0.918	Good
NNFI	> 0.9	0.924	Good
TLI	> 0.9	0.924	Good
AGFI	> 0.9	0.889	Near acceptable

Descriptive Statistics and Correlation Analysis

Table 6 shows means, standard deviations, and correlations. Digital transformation is positively correlated with teaching model change ($r = 0.523$, $p < 0.01$).

Table 6. Descriptive Statistics and Correlation Matrix of Key Variables

Variable	Mean	SD	1	2	3	4	5	6	7	8
1. Digital Transformation	3.42	0.61	1							
2. Tech Infrastructure	3.38	0.74	0.758^{**}	1						
3. Digital Resources	3.41	0.66	0.835^{**}	0.512^{**}	1					
4. Policy Support	3.47	0.69	0.821^{**}	0.468^{**}	0.674^{**}	1				
5. Digital Management	3.39	0.71	0.745^{**}	0.521^{**}	0.558^{**}	0.589^{**}	1			
6. Teaching Reform	3.56	0.58	0.523^{**}	0.412^{**}	0.445^{**}	0.398^{**}	0.387^{**}	1		
7. Instructional Design	3.61	0.64	0.465^{**}	0.375^{**}	0.401^{**}	0.362^{**}	0.351^{**}	0.875^{**}	1	
8. Teaching Methods	3.58	0.59	0.487^{**}	0.390^{**}	0.418^{**}	0.376^{**}	0.368^{**}	0.912^{**}	0.712^{**}	1
9. Assessment Practices	3.48	0.67	0.443^{**}	0.352^{**}	0.385^{**}	0.354^{**}	0.335^{**}	0.841^{**}	0.651^{**}	0.687^{**}

Note: ** indicates significance at the 0.01 level.

All sub-dimensions of digital transformation are positively correlated with teaching model change and its sub-dimensions (ranging from 0.335 to 0.487).

Regression Analysis Results

Overall Impact of Digital Transformation on Teaching Model Reform

Multiple linear regression (Table 7) shows that digital transformation is positively associated with teaching model change ($\beta = 0.523$, $p < 0.001$), explaining 27.3% of the variance ($\Delta R^2 = 0.273$), supporting H1.

Table 7. Regression Results: Impact of Digital Transformation on Teaching Model Reform

Variable	Model 1 (Controls Only)	Model 2 (Total Digital Transformation)	Model 3 (By Dimensions)
Control Variables			
Education	0.105^{*}	0.089^{*}	0.082^{*}
Title	0.142^{**}	0.128^{**}	0.121^{**}
Teaching Experience	−0.068	−0.051	−0.048
Gender	0.091^{*}	0.076	0.073
Independent Variables			
Digital Transformation (Total)		0.523^{***}	
Technological Infrastructure			0.279^{***}
Digital Resource Development			0.193^{***}
Policy Support			0.157^{***}
Digital Management			0.163^{***}
Model Statistics			
R^2	0.046	0.319	0.337
Adjusted R^2	0.037	0.311	0.324
F-value	5.342^{***}	41.208^{***}	26.745^{***}
ΔR^2	—	0.273	0.018

Note: * $p < 0.05$, * * $\boldsymbol{p < 0.01}$, * * * $p < 0.001$

When broken down into four dimensions, perceived technological infrastructure has the greatest association ($\beta = 0.279$), followed by digital resource development ($\beta = 0.193$), digital management ($\beta = 0.163$), and policy support ($\beta = 0.157$),supporting H2.

Table 8. Regression Results: Impact of Digital Transformation on Each Dimension of Teaching Reform

Independent Variable	Instructional Design (β)	Teaching Methods (β)	Assessment (β)
	β	β	β
Control Variables			
Education	0.087^{*}	0.091^{*}	0.064
Title	0.135^{**}	0.129^{**}	0.098^{*}
Teaching Experience	−0.042	−0.056	−0.045

Table 8. Regression Results: Impact of Digital Transformation on Each Dimension of Teaching Reform

Independent Variable	Instructional Design (β)	Teaching Methods (β)	Assessment (β)
Gender	0.078	0.081^{*}	0.059
Digital Transformation Dimensions			
Technological Infrastructure	0.186^{***}	0.215^{***}	0.157^{***}
Digital Resource Development	0.158^{***}	0.174^{***}	0.142^{***}
Policy Support	0.132^{**}	0.149^{***}	0.118^{*}
Digital Management	0.141^{***}	0.156^{***}	0.123^{*}
Model Statistics			
R^2	0.267	0.294	0.226
Adjusted R^2	0.253	0.281	0.211
F-value	19.756^{***}	22.658^{***}	15.827^{***}

Note: * $p < 0.05$, * * $\boldsymbol{p < 0.01}$, * * * $p < 0.001$

Differential associations across teaching components. Table 8 presents regression results for each teaching dimension. Digital transformation shows the strongest association with teaching methods ($R^2 = 0.294$), followed by instructional design ($R^2 = 0.267$), and assessment practices ($R^2 = 0.226$), supporting H3.

Structural Equation Modeling Analysis

Path Coefficient Analysis

Table 9 presents standardized path coefficients. The direct association from digital transformation (second-order latent variable) to teaching model change is 0.523 ($p < 0.001$).

Table 9. Path Coefficient Analysis of the Structural Equation Model

Path Relationship	Standardized Coefficient	t-value	p-value	Support
Digital Transformation → Teaching Model Reform	0.523	12.847	0	Supported (H1)
The components of digital transformation				
Technological Infrastructure ← Digital Transformation	0.758	—	—	
Digital Resource Development ← Digital Transformation	0.835	19.245	0	
Policy Support ← Digital Transformation	0.821	18.674	0	
Digital Management ← Digital Transformation	0.745	16.892	0	
The components of teaching model reform				
Instructional Design ← Teaching Model Reform	0.875	-	-	

Table 9. Path Coefficient Analysis of the Structural Equation Model

Path Relationship	Standardized Coefficient	t-value	p-value	Support
Teaching Methods ← Teaching Model Reform	0.912	24.517	0.000	
Teaching Evaluation ← Teaching Model Reform	0.841	22.385	0.000	
The direct impact of various dimensions of digital transformation on changes in teaching models				
Technological infrastructure → Instructional design	0.440	8.892	0.000	
Technological infrastructure → Teaching methods	0.394	8.156	0.000	
Technological infrastructure → Teaching assessment	0.305	6.287	0.000	
Technological infrastructure → Teaching assessment	0.305	6.287	0.000	
Digital resource development → Instructional design	0.378	7.845	0.000	
Digital resource development → Teaching methods	0.362	7.552	0.000	
Digital resource development → Teaching assessment	0.289	5.978	0.000	

Among the dimensions of digital transformation, digital resource development has the highest loading (0.835), followed by policy support (0.821), perceived technological infrastructure (0.758), and digital management (0.745). Among teaching change dimensions, teaching methods has the highest loading (0.912), then instructional design (0.875), and assessment (0.841).

Mediation Effect Analysis

Bootstrap mediation analysis (Table 10) shows that each dimension of digital transformation is associated with teaching model change primarily through the overall digital transformation construct, with mediation proportions ranging from 74.6% to 83.5%..

Table 10. Mediation Effect Analysis of Digital Transformation Dimensions on Teaching Model Change

Mediation Pathway	Indirect Effect	Direct Effect	Total Effect	Mediation Proportion	Significance
Technological Infrastructure → Digital Transformation → Teaching Model Change	0.397	0.126	0.523	75.90%	***
Digital Resource Development → Digital Transformation → Teaching Model Change	0.437	0.086	0.523	83.50%	***
Policy Support → Digital Transformation → Teaching Model Change	0.43	0.093	0.523	82.20%	***
Digital Management → Digital Transformation → Teaching Model Change	0.39	0.133	0.523	74.60%	***

Note: *** indicates $p < 0.001$

Moderation Effect Analysis

Teacher education and professional title positively moderate the association between digital transformation and teaching model change ($p < 0.05$), while teaching experience and gender show no significant moderation (Table 11).

Table 11. Analysis of the Moderating Effects of Individual Characteristics

Moderating Variable	Moderating Effect Coefficient	t-value	p-value	Nature of Moderating Effect
Educational Background	0.087	2.154	0.032	Positive Moderation
Professional Title	0.126	3.089	0.002	Positive Moderation
Teaching Experience	−0.052	−1.274	0.203	No Significant Moderation
Gender	0.041	1.003	0.316	No Significant Moderation

Robustness Test

A split-sample approach (randomly dividing the full sample into two halves, n_1=223, n_2=224) and re-estimating the SEM showed path coefficients of 0.518 and 0.527 respectively (both $p < 0.001$), confirming the stability of the findings. (The originally planned alternative variable test using digital competency was omitted because it would conflate an individual trait with an institutional process.)

RESULTS AND DISCUSSION

Key Findings

This study empirically examines the associations between digital transformation and teaching model change among apparel engineering educators at application-oriented undergraduate institutions in Jiangxi Province. The main findings are as follows:

(1) Digital transformation is positively associated with teaching model change

It explains 27.3% of the variance ($\beta = 0.523$, $p < 0.001$). Digital tools such as 3D design software and virtual fitting systems are shifting teacher-centered to student-centered experiential approaches.

(2) The mechanisms of different dimensions of digital transformation vary

Perceived technological infrastructure shows the strongest direct association ($\beta = 0.279$), followed by digital resource development ($\beta = 0.193$) and digital management ($\beta = 0.163$). Policy support's association is largely indirect.

(3) The impact of digital transformation varies across different teaching components

Teaching methods are most strongly associated with digital transformation ($R^2 = 0.294$), followed by instructional design (0.267) and assessment practices (0.226). This reflects a progressive pattern: teachers first adopt digital tools in content delivery, then in design, and finally in assessment—the latter facing greater institutional and cognitive barriers.

Why Does Assessment Lag Behind?

Assessment practices are less responsive to digital transformation than teaching methods and instructional design. Several factors may explain this. First, institutional inertia: grading policies and examination regulations are often tightly coupled with accreditation and quality assurance, making them resistant to change. Second, technological affordance: while tools for content delivery (e.g., LMS, video conferencing) are mature and user-friendly, formative assessment analytics require integration of multiple data streams (e.g., CAD software logs, peer evaluation platforms) that many institutions lack. Third, teacher cognition: educators perceive assessment as high-stakes, where innovation carries greater risk of error or unfairness, leading to slower adoption. Future research should test these hypotheses using qualitative methods.

Theoretical Contributions

This study makes several contributions.First, it constructs a multidimensional framework (technology–policy–management–resources) for digital transformation and a three-dimensional framework for teaching model change,providing measurement tools for future research.Second, it validates the associational pathways and reveals the indirect role of policy support, highlighting the systemic nature of digital transformation. Third, it enriches the literature on digital transformation in application-oriented undergraduate institutions, which have been understudied compared to comprehensive universities or vocational colleges.

Practical Implications

Education administrators should prioritize perceived technological infrastructure (e.g., 3D design labs, virtual simulation platforms), enhance digital resource development (e.g., discipline-specific case databases), and establish systematic policies covering funding, teacher training, and incentive systems. Digital management mechanisms (teaching quality monitoring, technical support) should also be optimized. Given the differential impact across teaching components and the moderating role of teacher education and professional title, a tiered support strategy tailored to teacher characteristics is recommended.

Limitations and Future Research

This study has several limitations. First, sample generalizability: the sample is limited to Jiangxi Province; regional disparities in digital economic development may limit generalizability. Future cross-regional comparisons are needed. Second, cross-sectional design: data were collected at a single time point, so causal claims cannot be made. Longitudinal designs (e.g., LCGM) are needed to analyze transformation stages. Third, measurement: perceived technological infrastructure was measured by teacher self-reports rather than objective institutional data. Future studies should combine both. Fourth, gender imbalance: the sample is predominantly female (68.23%), reflecting the disciplinary composition of apparel engineering. While we found no evidence of gender moderation (see Table 11), future studies with more balanced samples are needed. Fifth, micro-level mechanisms: we did not deeply explore teachers' digital identity or disciplinary cultural tensions. Future research should integrate qualitative methods (e.g., CDA, MMIA) to examine these aspects. Sixth, omitted variable bias: unobserved confounders (e.g., institutional culture, prior digital literacy) may influence both perceptions of digital transformation and engagement in teaching reform.

CONCLUSION

This study empirically demonstrates that digital transformation is positively associated with teaching model change among apparel engineering educators in application-oriented undergraduate institutions. The association is strongest for teaching methods, followed by instructional design and assessment. Perceived technological infrastructure plays the most prominent direct role, while policy support operates indirectly. These findings provide empirical grounding for advancing digital transformation in application-oriented universities and for designing differentiated teacher support strategies. Future research should adopt longitudinal, multi-regional, and mixed-method designs to deepen understanding of the causal mechanisms and contextual contingencies.

Author Contributions

Conceptualization – Wen J and Yang C; methodology – Wen J, Yang C and Yang S; formal analysis – Wen J and Yang C; investigation – Wen J, Chao H and Bungbua P; resources – Wen J and Chao H; writing-original draft preparation – Wen J; writing-review and editing – Yang C, Yang S, Chao H and Bungbua P; visualization – Wen J; supervision – Yang C and Yang S. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Funding

This research was funded by the Science and Technology Research Project of Jiangxi Provincial Department of Education (CN), grant number GJJ2502711; This research was funded by the Jiangxi Provincial Higher Education Humanities and Social Sciences Research Project (CN), grant number JY25206.

Human Research Subjects

This study involved human participants. All participants provided informed consent before taking part in the questionnaire survey and interviews, and participated voluntarily based on a full understanding of the purpose of the study, the use of the data, and their right to withdraw at any stage. To protect participants' privacy, all relevant data were anonymised during the research process, and any personally identifiable information was removed or concealed to ensure that no individual privacy would be disclosed in the reporting of the findings. All data were used solely for academic research and in strict accordance with relevant ethical standards.

Acknowledgements

The authors would like to express their sincere gratitude to the applied undergraduate universities in Jiangxi Province and the teachers of garment engineering who participated in this study for their active cooperation during the questionnaire survey and interviews. Meanwhile, the authors also wish to thank the teaching administration departments and relevant staff of the participating universities for their support and assistance in data collection and the organisation and implementation of the research.

REFERENCES

[1] Kocaoglu B, Kirmizi M. Prescriptive digital transformation maturity model: a development and validation study. Kybernetes. 2025;54(5):2662-2705. doi: 10.1108/K-02-2023-0243

[2] Carmo JES, Lacerda DP, Klingenberg CO, Piran FAS. Digital transformation in the management of higher education institutions. Sustain Futures. 2025;9:100692. doi: 10.1016/j.sftr.2025.100692

[3] Sembey R, Hoda R, Grundy J. Emerging technologies in higher education as-sessment and feedback practices: a systematic literature review. J Syst Softw. 2024;211:111988. doi: 10.1016/j.jss.2024.111988

[4] Casciani D, Chkanikova O, Pal R. Exploring the nature of digital transformation in the fashion industry: opportunities for supply chains, business models, and sustainability-oriented innovations. Sustainability: Science, Practice, & Policy. 2022;18(1):773-795. doi: 10.1080/15487733.2022.2125640

[5] Rosca E, Reedy J, Bendul JC. Does frugal innovation enable sustainable devel-opment? A systematic literature review. Eur J Dev Res. 2018;30(1):136-157. doi: 10.1057/s41287-017-0106-3

[6] Gumaelius L, Skogh IB, Matthíasdóttir Á, Pantzos P. Engineering education in change: a case study on the impact of digital transformation on content and teaching methods in different engineering disciplines. Eur J Eng Educ. 2024;49:70-93. doi: 10.1080/03043797.2023.2285794

[7] Xu J, Yu Y, Zhang M, Zhang JZ. Impacts of digital transformation on eco-innovation and sustainable performance: evidence from Chinese manufac-turing companies. J Clean Prod. 2023;393:136278. doi: 10.1016/j.jclepro.2023.136278

[8] Gao J, Jamil MRM, Zalli MM, Ahmad AM, Wang C, Wang H. Multimodal teaching strategies and effectiveness in vocational colleges' fashion programs. J Mod Educ Theory Pract. 2025;1(3). doi: 10.70767/jmetp.v1i3.463

[9] Wang Q, Qv N. Research on course design and teaching mode of "Clothing Marketing" under the background of integration of production and education. J Soc Sci Humanit Lit. 2023;6(5):101-108. doi: 10.53469/jsshl.2023.06(05).15