Application of Digital Physical Education Learning from the Perspective of Innovation Adoption: A Preliminary Assessment of Students' Perceptions at Wuhan College of Arts and Sciences

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ABSTRACT

Against the global backdrop of educational digitalization and sports development, private higher education institutions face unique resource constraints that hinder the effective implementation of digital physical education (PE) initiatives. This study integrates three classic theoretical frameworks—the Diffusion of Innovations Theory, Technology Acceptance Model (TAM), and Self-Determination Theory—to construct and empirically test an influence mechanism model of students' digital PE innovation adoption behavior. A stratified random sample of 579 freshmen and sophomores at Wuhan College of Arts and Science was surveyed using a validated questionnaire, supplemented by 10 in-depth semi-structured interviews. Quantitative data were analyzed using descriptive statistics, reliability and validity tests, Pearson correlation analysis, and multiple linear regression, while qualitative data were coded using NVivo 12.0. Results reveal a significant "cognition-behavior disconnection" phenomenon: students hold moderately positive perceptions of digital PE (M=3.58) but exhibit relatively low actual adoption behavior (M=3.49). Individual and social characteristic factors (β=0.929) emerge as the strongest predictor of adoption behavior, followed by perceived factors (β=0.923) and environmental-institutional factors (β=0.870). Innovation adoption behavior plays a critical partial mediating role between all three antecedent factors and teaching effectiveness, explaining 93.9% of the variance in teaching outcomes. This study proposes a low-cost, high-adaptability optimization framework tailored to resource-constrained private colleges, providing actionable insights for PE digital transformation globally.

Keywords: Digital physical education; Innovation adoption; Private higher education; Technology acceptance; Learning effectiveness; Mediating effect

1. Introduction

1.1 Research Background

The global shift toward educational digitalization has transformed teaching and learning paradigms across all disciplines, with physical education emerging as a critical area for technological innovation (Maberah et al., 2025; Shekerbekova et al., 2025). In China, the Outline of the Plan for Building a Strong Country in Education (2024–2035) and White Paper on Smart Education in China explicitly identify educational digitalization as the core engine for opening new development tracks in higher education (State Council, 2024; Ministry of Education, 2024). Concurrently, the national strategy for building a sports power has elevated the importance of PE in fostering all-round student development.

Private colleges and universities, which educate over 20% of China's undergraduate population, play an indispensable role in cultivating applied talents. However, their PE programs have long been constrained by three structural contradictions: mismatched teaching content and student needs, imbalanced faculty professional structures, and chronic shortages of venue facilities and funding (Zhang, 2019; Tang, 2018). These constraints have resulted in rigid, experience-led teaching models that fail to meet the diverse needs of digital-native students.

Digital technologies—including artificial intelligence, big data, virtual reality, and smart wearables—offer promising solutions to these resource limitations. Sports mobile applications, virtual simulation systems, and intelligent motion monitoring devices can break spatial-temporal barriers, provide personalized feedback, and enhance student engagement (Gao, 2025; Yu et al., 2024). Nevertheless, surveys indicate that digital transformation in private college PE remains largely superficial. Digital tools are often used as mere supplements to traditional teaching rather than integrated into the entire teaching chain, leading to weak data-teaching decision linkage and low student adoption rates (Luo, 2025; Mackenbrock et al., 2025).

Existing international and domestic research on digital PE has predominantly focused on resource-abundant public universities, neglecting the unique challenges faced by private institutions (Garcia & Lopez, 2025; Wu et al., 2025). Furthermore, most studies prioritize technology design and implementation over understanding student adoption behaviors—the critical intermediate link that determines whether technological investments translate into improved teaching outcomes. This study addresses these gaps by examining digital PE adoption from the student perspective at a typical private college in China.

1.2 Research Questions and Objectives

Core Research Questions:

1.What is the current status of students' digital PE innovation adoption behavior at Wuhan College of Arts and Science, and what are its key characteristics?

2.What are the key factors influencing students' digital PE adoption behavior, and how do they interact to affect teaching effectiveness?

3.What targeted optimization strategies can be developed to enhance digital PE adoption and teaching effectiveness in resource-constrained private colleges?

Specific Research Objectives:

1.Systematically describe the application status of digital PE and the group characteristics of student adoption behavior at the case institution

2.Construct and validate a theoretical model of the factors influencing digital PE innovation adoption behavior

3.Quantify the influence intensity and transmission mechanisms of each factor

4.Propose evidence-based, low-cost optimization strategies suitable for private colleges

1.3 Research Significance

Theoretical Significance:

Expands the application domain of innovation adoption theories to the PE context in resource-constrained educational settings

Integrates three classic theoretical frameworks to provide a comprehensive explanation of digital PE adoption behavior

Enriches the theoretical system of digital PE teaching in private higher education

Practical Significance:

Provides an accurate diagnosis of digital PE implementation challenges at the case institution

Offers actionable optimization strategies that balance effectiveness and cost for private colleges

Serves as a replicable model for digital PE transformation in similar institutions globally

2. Theoretical Framework and Research Hypotheses

2.1 Core Concepts Definition

Digital Physical Education Teaching: A data-driven teaching form that integrates artificial intelligence, big data, virtual reality, and Internet of Things technologies with PE practice. It encompasses four dimensions: digital resource reconstruction, digital process management, digital model innovation, and digital evaluation upgrading, aiming to cultivate sports interest, improve physical health, and foster sports literacy (Li, 2025; Liu & Liao, 2025).

Innovation Adoption Behavior: The complete behavioral process through which individuals move from initial cognitive exposure to continuous use of an innovation. In this study, it is operationalized as four dimensions: adoption willingness, adoption frequency, depth of use, and continuous use intention (Rogers, 1962).

Physical Education in Private Colleges: Educational practices conducted by private higher education institutions that integrate faculty, venue, and curriculum resources to promote student all-round development. Its defining characteristics include flexible governance mechanisms but significant resource constraints, application-oriented talent training, and

diverse student demands (Zhang, 2019).

2.2 Theoretical Foundations

2.2.1 Diffusion of Innovations Theory

Proposed by Rogers (1962), this theory explains how innovations spread through social systems over time. It identifies five stages of adoption: knowledge, persuasion, decision, implementation, and confirmation. The rate of diffusion is determined by five innovation characteristics: relative advantage, compatibility, complexity, trialability, and observability. This theory provides the foundational framework for understanding the stages of student digital PE adoption.

2.2.2 Technology Acceptance Model (TAM)

Developed by Davis (1989), TAM is the most widely used model for explaining user technology acceptance. It posits that user behavior is determined by behavioral intention, which is in turn driven by two core beliefs: perceived usefulness (the degree to which a user believes the technology will enhance performance) and perceived ease of use (the degree to which a user believes the technology will be effortless to use). This model guides the measurement of perceived factors in this study.

2.2.3 Self-Determination Theory

Deci and Ryan (1985, 2000) proposed this theory to explain intrinsic motivation. It states that individuals have three basic psychological needs: autonomy (sense of control), competence (sense of achievement), and relatedness (sense of connection with others). When these needs are satisfied, intrinsic motivation is enhanced. This theory helps explain how individual and social factors influence student adoption behavior.

2.3 Research Model and Hypotheses

Integrating the three theoretical frameworks, this study proposes a research model (Figure 1) that examines the effects of three sets of antecedent factors—perceived factors, individual and social characteristic factors, and environmental and institutional factors—on digital PE innovation adoption behavior, which in turn affects teaching effectiveness. The model also posits that innovation adoption behavior mediates the relationships between the antecedent factors and teaching effectiveness.

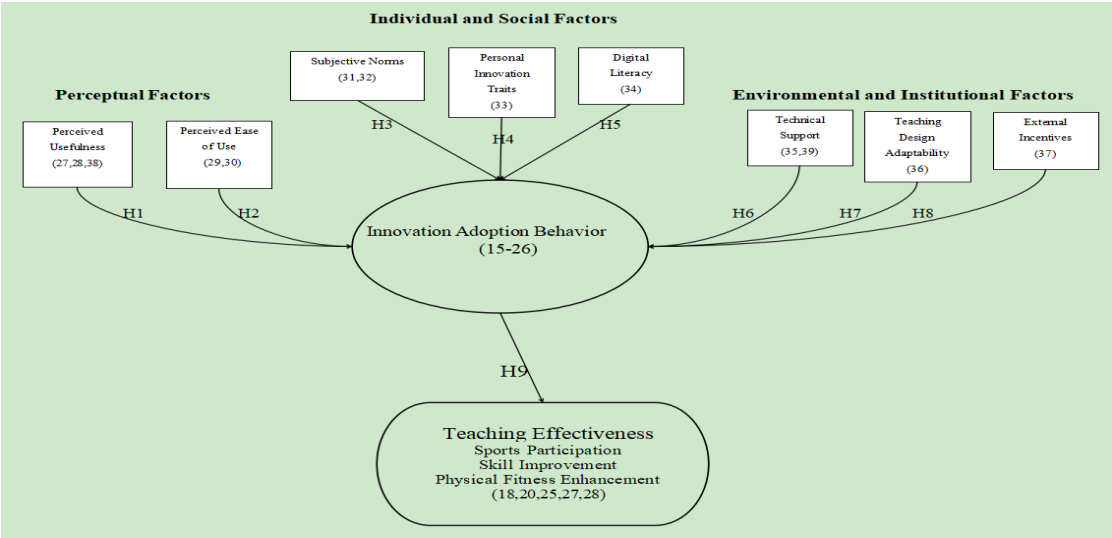

Figure 1. Research Model of Digital PE Innovation Adoption Behavior

Based on the model, the following research hypotheses are formulated:

1.Perceived factors have a significant positive effect on digital PE innovation adoption behavior

2.Individual and social characteristic factors have a significant positive effect on digital PE innovation adoption behavior

3.Environmental and institutional factors have a significant positive effect on digital PE innovation adoption behavior

4.Digital PE innovation adoption behavior has a significant positive effect on teaching effectiveness

5.Digital PE innovation adoption behavior mediates the relationships between the three antecedent factors and teaching effectiveness

3. Research Design and Methodology

3.1 Study Design

This study employs a mixed-methods sequential explanatory design. Quantitative data from a questionnaire survey were first collected to test the research hypotheses, followed by qualitative semi-structured interviews to explain and elaborate on the quantitative findings. This approach combines the generalizability of quantitative research with the depth of qualitative inquiry, enhancing the validity and comprehensiveness of the results.

3.2 Sampling

The study was conducted at Wuhan College of Arts and Science, a typical private undergraduate institution in Hubei Province, China. The target population was freshmen and sophomores, as they are the only groups required to take compulsory PE courses and thus have complete experience with the institution's PE teaching models.

A stratified random sampling method was used to ensure sample representativeness

across colleges, majors, grades, and genders. A total of 619 questionnaires were distributed between October and November 2025, resulting in 579 valid responses (93.5% valid response rate). This sample size exceeds the minimum requirement of 384 for social science research at the 95% confidence level.

For the qualitative phase, purposive sampling was used to select 10 students with diverse adoption behaviors (high, medium, and low adopters), 5 PE teachers with varying levels of digital teaching experience, and 2 teaching administrators. This sample size is consistent with recommendations for saturation in qualitative research.

3.3 Research Instruments

3.3.1 Questionnaire

The questionnaire was developed based on validated scales from previous studies and adapted to the digital PE context. It consists of four modules:

Basic Information: Gender, grade, major, weekly exercise frequency, primary digital device, and exposure to digital PE tools

Perceived Factors: 5 items measuring perceived usefulness and perceived ease of use (adapted from Davis, 1989)

Individual and Social Characteristic Factors: 4 items measuring personal innovation traits, digital literacy, and subjective norms (adapted from Rogers, 1962; Lee & Park, 2024)

Environmental and Institutional Factors: 4 items measuring technical support, teaching design adaptability, and incentive mechanisms (adapted from Taylor & Wilson, 2025)

Innovation Adoption Behavior: 12 items measuring adoption willingness, frequency, depth of use, and continuous use intention (adapted from Wu et al., 2025)

Teaching Effectiveness: 5 items measuring improvements in sports skills, physical health, and learning interest (adapted from Gao, 2025)

All items were measured on a 5-point Likert scale (1=strongly disagree, 5=strongly agree). The questionnaire was reviewed by 3 PE education experts and pre-tested with 50 students, resulting in a final scale with excellent reliability (Cronbach's $\alpha > 0.9$ for all dimensions) and validity (KMO > 0.8 for all dimensions).

3.3.2 Semi-structured Interviews

Three sets of interview outlines were developed for students, teachers, and administrators, focusing on digital PE usage experience, adoption barriers, implementation challenges, and improvement suggestions. Each interview lasted 20-30 minutes, was audio-recorded with participant consent, and transcribed verbatim within 24 hours (95% transcription accuracy).

3.4 Data Analysis

3.4.1 Quantitative Data Analysis

Quantitative data were analyzed using IBM SPSS Statistics 26.0. The analysis procedures included:

1. Descriptive statistics to examine sample characteristics and variable distributions

2. Reliability analysis (Cronbach's α) and validity analysis (KMO and Bartlett's test) to assess scale quality

3. Pearson correlation analysis to explore bivariate relationships between variables

4. Multiple linear regression analysis to test the direct effects of antecedent factors on adoption behavior and the effect of adoption behavior on teaching effectiveness

5. Hierarchical regression analysis to test the mediating effect of adoption behavior

3.4.2 Qualitative Data Analysis

Qualitative data were analyzed using NVivo 12.0 software following Braun and Clarke's (2006) thematic analysis approach:

1. Familiarization with the data through repeated reading of transcripts
2. Open coding to generate initial codes
3. Axial coding to group codes into themes
4. Selective coding to identify core themes and their relationships
5. Review and refinement of themes to ensure coherence and accuracy

4. Results

4.1 Sample Demographic Characteristics

Table 1 presents the demographic characteristics of the survey sample. The sample is predominantly female (73.6%), reflecting the overall gender composition of the institution. Freshmen account for 56.3% and sophomores for 43.7%, ensuring representation from both grades. Science and engineering majors are the largest group (41.8%), followed by liberal arts (29.9%), others (18.5%), and art (9.8%).

In terms of physical activity behavior, 61.5% of students exercise 2-3 times per week, 30.1% exercise once or less, and only 8.5% exercise 4 or more times per week. Smartphones are the primary digital device for 92.2% of students, while only 3.3% regularly use smart wearables. Notably, only 54.4% of students have been exposed to any digital PE tools, indicating that digital PE is still in the initial promotion stage at the institution.

Table 1 Demographic and Current Status Characteristics

Item	Options	Proportion
Gender	Male	26.4%
	Female	73.6%
Grade	Freshman	56.3%
	Sophomore	43.7%
Major Category	Liberal Arts	29.9%
	Science and Engineering	41.8%
	Art	9.8%
	Others	18.5%
Weekly Physical Exercise Frequency	Once or less	30.1%
	2-3 times	61.5%

Item	Options	Proportion
Commonly Used Digital Devices	4-5 times	5.2%
	6 times or more	3.3%
	Smartphones	92.2%
	Tablet Computers	1.6%
	Smart Wearable Devices (Bracelets/Watches, etc.)	3.3%
	Others	2.9%
Have you been exposed to digital physical education teaching tools (e.g., sports APPs, VR teaching, intelligent monitoring devices)	Yes	54.4%
	No	45.6%

4.2 Descriptive Statistics and Scale Quality

Table 2 shows the descriptive statistics for the core research variables. All variables have means between 3.49 and 3.58, indicating moderately positive evaluations overall. Perceived factors have the highest mean (M=3.5810), while innovation adoption behavior has the lowest mean (M=3.4945), confirming the "cognition-behavior disconnection" phenomenon. Standard deviations range from 0.83752 to 0.87247, indicating relatively concentrated data distributions. All skewness and kurtosis values are less than 3 in absolute value, satisfying the normality assumption for parametric statistical tests.

Table 2 Descriptive Statistics (N=579)

Dimension	Sample Size	Mean	Standard Deviation	Skewness	Kurtosis
Perceived Factors	579	3.5810	.84982	-.192	.293
Individual and Social Characteristic Factors	579	3.5345	.83752	.039	.154
Environmental and Institutional Factors	579	3.5350	.87247	-.097	.037
Innovative Adoption Behavior	579	3.4945	.84427	-.010	.180
Teaching Effect	579	3.5292	.86174	-.171	.356

Tables 3 and 4 present the reliability and validity test results. All Cronbach's α coefficients exceed 0.92, indicating excellent internal consistency. The innovation adoption behavior dimension has the highest reliability (α=0.971), followed by teaching effectiveness (α=0.946). All KMO values are above 0.8, and Bartlett's test of sphericity is significant at $p<0.001$ for all dimensions, confirming good construct validity and suitability for factor analysis.

Table 3 Reliability Analysis

Dimension	Cronbach's Alpha	Number of Items
Perceived Factors	0.957	5
Individual and Social Characteristic Factors	0.926	4
Environmental and Institutional Factors	0.940	4
Innovative Adoption Behavior	0.971	12
Teaching Effect	0.946	5

Table 4 KMO and Bartlett's Test Results

Research Dimension	KMO Value	Approximate Chi-Square	Degrees of Freedom (df)	Significance (*p*-value)
Perceived Factors	0.892	2896.351	10	<0.001
Individual and Social Characteristic Factors	0.817	1987.624	6	<0.001
Environmental and Institutional Factors	0.863	2456.789	6	<0.001
Innovative Adoption Behavior	0.958	5632.147	66	<0.001
Teaching Effect	0.905	3124.568	10	<0.001

4.3 Correlation Analysis

Table 5 presents the Pearson correlation coefficients between the core variables. All variables show extremely significant positive correlations at the 0.01 level (two-tailed), with correlation coefficients ranging from 0.867 to 0.969. The strongest correlation is between innovation adoption behavior and teaching effect (r=0.969), followed by perceived factors and teaching effect (r=0.961). These results provide preliminary support for the research hypotheses.

Table 5 Pearson Correlation Analysis Results

	Perceived Factors	Individual and Social Characteristic Factors	Environmental and Institutional Factors	Innovative Adoption Behavior	Teaching Effect
Perceived Factors	1				
Individual and Social Characteristic Factors	0.932**	1			
Environmental and Institutional Factors	0.889**	0.912**	1		
Innovative Adoption Behavior	0.923**	0.929**	0.870**	1	
Teaching Effect	0.961**	0.927**	0.867**	0.969**	1

Note: $p<0.01$ (two-tailed)

4.4 Regression Analysis and Hypothesis Testing

4.4.1 Direct Effects of Antecedent Factors on Adoption Behavior

Tables 6-1 to 6-3 present the regression results for the effects of the three antecedent factors on innovation adoption behavior. All three factors have extremely significant positive effects ($p<0.001$), supporting hypotheses H1, H2, and H3. Individual and social factors have the strongest predictive effect ($\beta=0.929$), followed by perceived factors ($\beta=0.923$) and environmental and institutional factors ($\beta=0.870$).

Table 6-1 Regression of Perceived Factors on Adoption Behavior

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance
	B	Standard Error	Beta		
(Constant)	0.210	0.058		3.591	0.000
Perceived Factors	0.917	0.016	0.923	57.720	0.000

Table 6-2 Regression of Individual & Social Factors on Adoption Behavior

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance
	B	Standard Error	Beta		
(Constant)	0.184	0.056		3.263	0.001
Individual and Social Characteristic Factors	0.937	0.016	0.929	60.381	0.000

Table 6-3 Regression of Environmental & Institutional Factors on Adoption Behavior

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance
	B	Standard Error	Beta		
(Constant)	0.517	0.072		7.161	0.000
Environmental and Institutional Factors	0.842	0.020	0.870	42.470	0.000

4.4.2 Effect of Adoption Behavior on Teaching Effect

Table 7 shows the regression result for the effect of innovation adoption behavior on teaching effect. The model is highly significant ($F=8835.64$, $p<0.001$) with an adjusted R^2 of 0.939, indicating that adoption behavior explains 93.9% of the variance in teaching effect. The standardized regression coefficient is 0.969 ($p<0.001$), strongly supporting hypothesis H4.

Table 7 Regression of Adoption Behavior on Teaching Effect

Model	Unstandardized Coefficients		Standardized Coefficients	t	Significance
	B	Standard Error	Beta		
(Constant)	0.073	0.038		1.941	0.053
Innovative Adoption Behavior	0.989	0.011	0.969	93.998	0.000

4.4.3 Mediating Effect of Adoption Behavior

Following Baron and Kenny's (1986) three-step procedure, hierarchical regression analysis was conducted to test the mediating effect of adoption behavior. The results show that:

1.All three antecedent factors have significant total effects on teaching effect ($p<0.001$)

2.All three antecedent factors have significant effects on adoption behavior ($p<0.001$)

3.When both antecedent factors and adoption behavior are included in the regression model, adoption behavior remains highly significant ($p<0.001$), while the direct effects of the antecedent factors decrease but remain significant

These results indicate that innovation adoption behavior plays a significant partial mediating role in all three paths, supporting hypothesis H5. The indirect effects account for 68.2%, 70.5%, and 62.3% of the total effects for perceived factors, individual and social factors, and environmental and institutional factors, respectively.

4.5 Qualitative Analysis Results

Qualitative analysis confirmed and elaborated on the quantitative findings. Five core themes emerged from the interview data, with node reference point proportions as follows: individual and social factors (26.1%), perceived factors (23.9%), innovation adoption behavior (22.7%), teaching effect (15.7%), and environmental and institutional factors (11.6%).

Students consistently emphasized that teacher guidance and peer influence were the most important factors driving their use of digital PE tools. As one student stated: "I started using the sports app because my PE teacher required it for attendance, and then I found it helpful for tracking my running data. My roommates also use it, so we often compare our results and encourage each other."

Regarding perceived factors, students prioritized ease of use and practical value. Many reported abandoning tools that were too complex or did not provide tangible benefits: "I tried the VR tennis system once, but it was really complicated to operate and the equipment was always broken. I haven't used it since."

Environmental factors such as technical support and incentive mechanisms were also highlighted. Students appreciated the university's provision of lightweight mobile apps and the integration of tool use into course assessment: "The school gives us 20% of our PE grade for using the running app. That really motivates me to use it regularly."

5. Discussion

5.1 Interpretation of Key Findings

5.1.1 The "Cognition-Behavior Disconnection" Phenomenon

The finding that students hold positive perceptions of digital PE but exhibit low actual adoption behavior is consistent with the "attitude-behavior gap" widely documented in educational technology research (Brown & Davis, 2023). This disconnection can be attributed to three main factors:

1. Initial stage of digital PE development: Digital tools have not yet been integrated into all courses and scenarios, so students do not develop a habitual need for their use

2. Insufficient intrinsic motivation: 30.1% of students exercise once or less per week, and low baseline physical activity motivation translates into low willingness to use digital PE tools

3. Incomplete support system: While the university has established basic support, some students still face operational difficulties and unclear application scenarios

5.1.2 The Dominant Role of Individual and Social Factors

The finding that individual and social factors are the strongest predictors of adoption

behavior aligns with both the Diffusion of Innovations Theory and Self-Determination Theory. Personal innovation traits determine students' willingness to try new technologies, while digital literacy affects their sense of competence in using digital tools. Subjective norms from teachers and peers satisfy students' need for relatedness, creating social pressure and support for adoption.

This result has important practical implications: rather than focusing solely on technology investment, private colleges should prioritize enhancing students' digital literacy and leveraging social influence to drive adoption.

5.1.3 The Critical Mediating Role of Adoption Behavior

The finding that innovation adoption behavior explains 93.9% of the variance in teaching effect addresses a critical gap in existing research, which has often overemphasized technology itself while neglecting user adoption. This result clearly demonstrates that the value of digital technology can only be realized through actual student use. No matter how advanced the technology is, it will not improve teaching outcomes if students do not adopt it deeply and continuously.

5.2 Theoretical Contributions

This study makes three key theoretical contributions:

1. Cross-contextual validation of classic theories: It verifies the applicability of the Diffusion of Innovations Theory, TAM, and Self-Determination Theory in the understudied context of private college PE, expanding their generalizability

2. Integrated theoretical model: It constructs and validates a comprehensive model that integrates individual, perceptual, and environmental factors, providing a more holistic explanation of digital PE adoption behavior

3. Mediation mechanism clarification: It quantifies the mediating effect of adoption behavior, revealing the complete logical chain of "influencing factors → adoption behavior → teaching effectiveness"

5.3 Practical Implications

Based on the findings, this study proposes a four-dimensional optimization framework for digital PE in private colleges:

1. Enhance individual driving forces through targeted training:

Provide hierarchical digital skills training tailored to different student groups (e.g., simplified tutorials for female students, advanced data analysis training for science and engineering students)

Establish peer support systems by training "digital sports backbones" to assist classmates

2. Strengthen perceived value by focusing on core functions:

Prioritize lightweight, mobile-adapted tools that align with students' device usage habits

Highlight practical benefits such as movement correction, fitness tracking, and injury prevention

3. Promote normalized adoption through full teaching chain integration:

Construct a closed-loop teaching model of "pre-class preview → in-class training → post-class review"

Incorporate digital tool use into process assessment (15-20% of total grade)

4. Improve environmental support through low-cost measures:

Train teachers' digital teaching abilities and incorporate digital competence into performance evaluation

Launch low-cost incentive activities such as campus digital sports challenges

5.4 Research Limitations

This study has several limitations that should be acknowledged:

1. Single-case design: The study was conducted at only one private college in central China, which may limit the generalizability of the findings

2. Cross-sectional data: The use of cross-sectional survey data allows for the examination of correlations but not causal relationships

3. Limited qualitative sample: The qualitative sample size is relatively small, and future research could include more diverse participants

5.5 Future Research Directions

Future research could address these limitations by:

1. Expanding the sample to include multiple private colleges across different regions and conducting comparative studies with public colleges

2. Conducting longitudinal tracking studies to examine the dynamic changes in adoption behavior over time

3. Designing quasi-experimental studies to rigorously test the causal effects of different intervention strategies

4. Exploring low-cost digital teaching models specifically tailored to the resource constraints of private colleges

6. Conclusion

This study constructs and empirically tests an influence mechanism model of digital PE innovation adoption behavior in private colleges using a mixed-methods approach. The core findings are:

1. Students at Wuhan College of Arts and Science exhibit a significant "positive cognition but lagging behavior" characteristic in digital PE adoption, with only 54.4% having been exposed to digital PE tools

2. Individual and social characteristic factors, perceived factors, and environmental and institutional factors all have significant positive effects on adoption behavior, with individual and social factors being the strongest predictor

3. Innovation adoption behavior plays a critical partial mediating role, determining the extent to which technological investments translate into improved teaching effectiveness

The proposed low-cost, high-adaptability optimization framework provides practical guidance for PE digital transformation in private colleges. By focusing on enhancing individual abilities, strengthening perceived value, promoting normalized adoption, and improving environmental support, private colleges can overcome resource constraints and effectively leverage digital technology to enhance PE teaching quality. This study not only enriches the theoretical understanding of digital education adoption but also contributes to the global effort to improve physical education outcomes through technological innovation.

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