International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18 (2026) pp. 1-13

https://doi.org/10.70917/ijcisim-2026-2169
Article

Virtual Reality-Enhanced Teaching Environment and Learning Outcomes of Shanxi Folk Dance: The Moderating Role of Students' Technostress and Cultural Empathy

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Abstract: With the continuous development of virtual reality technology, new channels and path models have been provided for dance teaching in universities. This study aims to empirically analyze the moderating effects of students' technical anxiety and cultural empathy on virtual reality empowered teaching environment and the learning effectiveness of Shanxi folk dance. In addition, this article constructs an intelligent data collection and quantitative analysis system based on Python technology stack. At the same time, the BERT NLP Chinese text sentiment quantification algorithm is introduced to encode contextual semantics. The final analysis showed that the interaction coefficient of technology anxiety was significantly negative (β=-0.198, $p<0.001$), indicating that technology anxiety weakens the role of VR action demonstration in improving students' Shanxi folk dance skills; The interaction coefficient of technology anxiety is significantly negative (β=-0.221, $p<0.001$). From this perspective, there is a significant interaction between technology anxiety and cultural empathy in the VR empowered teaching environment and the learning effect of Shanxi folk dance. In order to strengthen the construction of virtual reality teaching in Shanxi, it plays a positive reference role.

Keywords: virtual reality empowerment; Teaching environment; Shanxi folk dance; Learning outcomes; Technology anxiety; Cultural empathy

1. Research background and hypotheses

1.1. Research background

Ethnic folk dance is an effective way to showcase ethnic customs, express sincere and passionate emotions, express love for life, and present ethnic history through rich body language. It has important significance in enhancing national cultural confidence. Shanxi folk dance is a primitive dance style that has been passed down in the Shanxi region, containing rich cultural connotations of the Three Jin dynasties and forming various unique symbolic languages. Within Shanxi province, there are Yangge dance, drum dance, lantern dance, and martial arts the dance forms such as class A and stilt are rich and diverse, which together convey the unique local characteristics of the Loess Plateau. Currently, due to the increasingly strong call for the inheritance of intangible cultural heritage, Shanxi folk dance is actively integrating into university dance schools in order to better promote and develop in the new era. This has milestone significance for the teaching of Shanxi folk dance [1]. However, in the actual implementation process, there are problems with unreasonable teaching forms, weak student interest, and low interest in teaching content in Shanxi folk dance classroom teaching, which hinder the improvement of the teaching effectiveness of Shanxi folk dance. In recent years, with the rapid

development of big data and intelligent technology, favorable conditions have been created for the application of virtual reality technology. As a technology form that simulates real scenes, how to use virtual reality technology to create high simulation, repeatable, and risk-free learning environments, and solve the dilemma of high risk, high cost, and difficult reproduction in traditional teaching, has become an important research topic in the field of education. Currently, virtual reality technology, with its core advantages such as immersive experience, interactive feedback, and scenario based simulation, has provided a new path for the development of the education industry. At the same time, it has also had a certain impact on the learning of folk dance in Shanxi. With the support of virtual reality technology, highly realistic teaching scenes of Shanxi folk dance can be constructed, breaking the limitations of time and space, allowing students to better understand and master the details of Shanxi folk dance performances in virtual scenes, achieving personalized exercises, and potentially solving the pain points of traditional teaching [2]. In this study, the virtual reality empowered teaching environment was used as the independent variable, the learning effect of Shanxi folk dance was used as the dependent variable, students' technical anxiety and cultural empathy were used as moderating variables, and students' gender, study years, use of virtual reality technology, and basic level of Shanxi folk dance were used as control variables, in order to effectively analyze and expound on the relationship between the virtual reality empowered teaching environment and the learning effect of Shanxi folk dance.

1.2. Research hypothesis

1.2.1. Hypothesis on the Impact of Virtual Reality Empowered Teaching Environment on the Learning Effect of Shanxi Folk Dance

Virtual reality empowers teaching environments through immersive scene simulation, precise action demonstrations, real-time interactive feedback, and other advantages. Zhang Aimin and Huang Yikun (2021) believe that nowadays, most college students are born in the 1990s and 2000s. The younger generation has a high acceptance of new media and is more willing to use it as a learning tool. The use of virtual reality technology can transform "invisible" theories into "visible" scenarios. It can effectively break through the limitations of traditional teaching, help students accurately master the movement skills of Shanxi folk dance, deeply understand the cultural connotations behind dance, and stimulate learning motivation. Based on existing research and theoretical analysis, the following hypotheses are proposed:

H1: The virtual reality empowered teaching environment has a significant positive impact on the learning effect of Shanxi folk dance.

H1a: The action demonstration dimension of virtual reality empowered teaching environment has a significant positive impact on the action skill dimension of Shanxi folk dance learning effect.

H1b: The scene simulation dimension of virtual reality empowered teaching environment has a significant positive impact on the cultural understanding dimension of the learning effect of Shanxi folk dance.

H1c: The interactive feedback dimension of virtual reality empowered teaching environment has a significant positive impact on the learning motivation dimension of Shanxi folk dance learning effectiveness.

1.2.2. Hypothesis on the moderating effect of technology anxiety

Technology anxiety is accompanied by the worship of technology. As early as the 1950s, the emergence of the first modern computers made humans feel the enormous potential of technology in promoting social development. At that time, many people believed that computer technology would disrupt life order and threaten human survival. Therefore, technology anxiety attracted the attention of many scholars. The "Technology Anxiety Scale" developed by Khasaw neh in 2018 includes 16 questions and is evaluated using a five point scale, which includes five factors: technology fear, technology tension, technology paranoia, control resistance, and avoidance of use [3]. Research has shown that this scale has high reliability and validity, and has subsequently become the main measurement tool for technology anxiety research. In 2022, Sun Erhong translated, back translated, and cross-cultural adjusted Khasaw neh's Technology Anxiety Scale, deleting 3 items and forming a Chinese version of the Scale with 13 items and 3 factors (technology tension, technology fear, privacy and security concerns). Research has shown that the Chinese version of the Scale has good reliability and validity. This study refers to Sun Erhong's description of technology anxiety. In this article, technology anxiety refers to the negative emotions that students experience when using virtual reality technology to learn Shanxi folk dance. It can reduce students' acceptance and participation in the virtual reality teaching environment, hindering the smooth progress of the learning process. When students

have a low level of technological anxiety, they can better adapt to the virtual reality empowered teaching environment, fully leverage their teaching advantages, and improve learning outcomes; When students have a high level of technological anxiety, it can distract their learning attention, reduce their learning initiative, and weaken the positive impact of virtual reality on the teaching environment [4]. Based on the technology acceptance model and cognitive load theory, the following hypotheses are proposed:

H2: Technology anxiety has a significant negative moderating effect on the relationship between VR enabled teaching environment and the learning effect of Shanxi folk dance.

H2a: Technology anxiety has a significant negative moderating effect between the action demonstration dimension of VR empowered teaching environment and the action skill dimension of learning effectiveness.

H2b: Technology anxiety has a significant negative moderating effect between the scene simulation dimension of VR enabled teaching environment and the cultural understanding dimension of learning outcomes.

H2c: Technology anxiety has a significant negative moderating effect between the interactive feedback dimension of VR enabled teaching environment and the learning motivation dimension of learning outcomes.

1.2.3. Hypothesis on the regulatory role of cultural empathy

Davis regards empathy as understanding the attitude or motivation of others. But some people often incorporate accuracy into their definition of cognitive empathy, as the relevance of empathy in these contexts often depends on whether the people interacting with them (such as patients, students) feel understood and respected. Emotional empathy refers to one person's emotional response to another. This emotional response includes both positive emotional responses (such as empathetic care); This also includes negative emotional reactions (such as personal pain). Cultural empathy can help students better understand the cultural connotations of Shanxi folk dance, generate emotional resonance, and stimulate learning motivation [5]. When students have a high level of cultural empathy, they can better adapt to scene simulation in VR empowered teaching environments, deeply explore the cultural value behind dance, and strengthen the empowering effect of virtual reality teaching environments; When students have a low level of cultural empathy, it is difficult for them to understand the cultural connotations of dance, and their learning initiative is insufficient, which will weaken the positive impact of virtual reality empowering the teaching environment. Based on the theory of cultural empathy, the following hypotheses are proposed:

H3: Cultural empathy has a significant positive moderating effect between the virtual reality empowered teaching environment and the learning effect of Shanxi folk dance.

H3a: Cultural empathy has a significant positive moderating effect between the action demonstration dimension of virtual reality empowered teaching environment and the action skill dimension of learning outcomes.

H3b: Cultural empathy has a significant positive moderating effect between the scenario simulation dimension of virtual reality empowered teaching environment and the cultural understanding dimension of learning outcomes.

H3c: Cultural empathy has a significant positive moderating effect between the interactive feedback dimension of virtual reality empowered teaching environment and the learning motivation dimension of learning outcomes.

1.2.4. Hypothesis on the interactive moderating effect of technological anxiety and cultural empathy

Technology anxiety and cultural empathy do not function independently, and there may be an interactive moderating effect between the two. When students have a high level of cultural empathy, it can effectively alleviate the negative impact of technology anxiety, help students better adapt to the virtual reality empowered teaching environment, and fully leverage the teaching advantages of virtual reality technology [6]; When students have a low level of cultural empathy, the negative moderating effect of technology anxiety will be further enhanced, seriously hindering the improvement of learning outcomes. Based on relevant theories and existing research, the following hypotheses are proposed:

H4: Technology anxiety and cultural empathy have a significant interactive moderating effect between the virtual reality empowered teaching environment and the learning effect of Shanxi folk dance. Specifically, the higher the level of cultural empathy, the weaker the negative moderating effect of technological anxiety; The lower the level of cultural empathy, the stronger the negative moderating effect of technological anxiety.

H4a: Technology anxiety and cultural empathy have a significant interactive moderating effect between the action demonstration dimension of virtual reality empowered teaching environment and the action skill dimension of learning outcomes.

H4b: Technology anxiety and cultural empathy have a significant interactive moderating effect between the scenario simulation dimension of virtual reality empowered teaching environment and the cultural understanding dimension of learning outcomes.

H4c: Technology anxiety and cultural empathy have a significant interactive moderating effect between the interactive feedback dimension of virtual reality empowered teaching environment and the learning motivation dimension of learning outcomes.

2. Research Design

2.1. Research object

This study focuses on students studying Shanxi folk dance in universities, selecting students from three universities in Shanxi Province that offer Shanxi folk dance courses (Shanxi University, Shanxi Normal University, Taiyuan University of Technology) and two folk dance training institutions as research subjects. In terms of selection criteria, students who are currently learning or have previously learned Shanxi folk dance (such as Jiangzhou Drum Music, Qixian Yangge Dance, Xiaoyi Shadow Puppetry Dance, etc.) and have previously used virtual reality technology to learn Shanxi folk dance are selected. They are allowed to voluntarily participate in questionnaire filling and experimental tasks. In the specific implementation, a control group and an experimental group are used for analysis. The control group adopts the traditional teaching mode, with a teaching cycle of 8 weeks, 2 times a week, and 60 minutes each time.

2.2. Data collection methods

By using a combination of online and offline methods to distribute the questionnaire, the questionnaire link was sent to the research subjects through the Wenjuanxing platform online. Offline, the questionnaire was distributed on-site by researchers in university dance classes and folk dance training institutions, who provided guidance on filling out the questionnaire. Before filling out the questionnaire, explain the research purpose and requirements to the research subjects, promise that the questionnaire data will only be used for academic research, strictly keep personal information confidential, and ensure that the research subjects fill out the questionnaire truthfully [7]. And data collection was conducted over a period of 4 weeks, with a total of 500 questionnaires distributed and 486 questionnaires collected, of which 462 were valid, resulting in an effective response rate of 92.4%. Sample structure of valid questionnaires: In terms of gender, 328 were female, accounting for 71.0%, and 134 were male, accounting for 29.0%; In terms of study years, 152 people have 1 year or less, accounting for 32.9%; 218 people in 1-3 years, accounting for 47.2%; 92 people over 3 years, accounting for 19.9%; In terms of experience in using virtual reality technology, 128 people have no experience, accounting for 7.7%; 236 people have a small amount of experience, accounting for 51.1%; 98 people with rich experience, accounting for 21.2%; In terms of basic level of folk dance, 102 people have zero foundation, accounting for 22.1%; 258 individuals, accounting for 55.8%, have a general foundation; 102 people have a good foundation, accounting for 22.1%.

Collect and analyze data in a targeted manner before and after the experiment. Before the experiment, pre-tests were conducted on the experimental group and control group students, including motor skill scores, cultural understanding questionnaires, and learning motivation questionnaires, to ensure that there was no significant difference in the basic level between the two groups of students (independent sample t-test, $p>0.05$.During the experiment, the experimental group used a virtual reality enabled teaching environment for teaching. Students watched action demonstrations through virtual reality devices, practiced in virtual scenes, and received real-time action feedback; The control group adopts the traditional teaching mode, with teachers demonstrating actions, classroom correction, and students imitating and practicing [8]. After the experiment, two sets of action skill scores, cultural understanding questionnaires, and learning motivation questionnaires were analyzed to record students' learning participation, practice duration, and other relevant information as auxiliary analysis data. Finally, complete and effective data information content was obtained.

3. Empirical analysis

3.1. Descriptive statistics

Through statistical analysis of the mean and standard deviation dimensions of virtual reality empowered teaching environment, learning effectiveness of Shanxi folk dance, technical anxiety, and cultural empathy, the specific results are shown in Table 1:

Table 1. Descriptive statistics of each variable

Variable	Dimension	Mean (M)	Standard deviation (SD)	Min	Max
Virtual reality empowers teaching environment	Action demonstration	3.12	0.54	1	5
	Scene simulation	3.30	0.61	1	5
	Interactive feedback	3.54	0.69	1	5
Learning effect and action skills of Shanxi	folk dance	3.62	0.72	1	5
	Cultural understanding	3.69	0.75	1	5
	Learning motivation				
Technical anxiety	Operational anxiety	3.54	0.60	1	5
	Equipment anxiety	3.63	0.67	1	5
	Effect anxiety				
Cultural Empathy	Understanding Empathy	3.63	0.59	1	5
	Resonance and Empathy	3.79	0.62	1	5
	Identification and Empathy	3.81	0.68	1	5

In terms of descriptive statistics controlling for variables, in terms of gender, the proportion of females is higher than that of males, which is in line with the group characteristics of folk dance learning; In terms of learning years, students with 1-3 years of experience have the highest proportion (47.2%), indicating that most students are in the middle stage of learning folk dance; In terms of experience in using virtual reality technology, students with a small amount of experience account for the highest proportion (51.1%), indicating that most students have some understanding of virtual reality technology, but limited experience in using it; In terms of the basic level of folk dance, students with average foundation have the highest proportion (55.8%), indicating that the research sample has strong representativeness.

3.2. Reliability and validity testing

Reliability testing refers to the reliability testing of a questionnaire, which refers to the degree of consistency in the results obtained by repeatedly measuring the same object using the same method, that is, the degree of reflection of the actual situation. The main methods for reliability testing are as follows:

(1) Cronbach's Alpha coefficient method,

(2) test-retest reliability method,

(3) duplicate reliability method,

(4) half fold reliability method [9].

This study used the most commonly used Cronbach's Alpha coefficient method for measurement. By conducting Cronbach's alpha coefficient tests on various scales, Table 2 showed that the Cronbach's alpha coefficient of the Virtual Reality Empowered Teaching Environment Scale was 0.887, and the alpha coefficients of each dimension ranged from 0.821 to 0.856; The Cronbach's alpha coefficient of the Technology Anxiety Scale is 0.864, and the alpha coefficients of each dimension are between 0.803-0.835; The Cronbach's alpha coefficient of the Cultural Empathy Scale is 0.879, and the alpha coefficients of each dimension range from 0.812 to 0.848; The Cronbach's alpha coefficient of the Shanxi Folk Dance Learning Effect Scale is 0.893, and the alpha coefficients of each dimension are between 0.834-0.867. The Cronbach's alpha coefficients of all scales are greater than 0.8, indicating good internal consistency and reliability of each scale.

Table 2. Reliability Test Analysis

Variable	Dimension	Cronbach's dimension	Cronbach's scale
Virtual reality empowers teaching environment	Action demonstration	0.821	0.887
	Scene simulation	0.837	
	Interactive feedback	0.856	
Learning effect and action skills of Shanxi	folk dance	0.834	0.893
	Cultural understanding	0.851	
	Learning motivation	0.867	
Technical anxiety	Operational anxiety	0.803	0.864
	Equipment anxiety	0.829	
	Effect anxiety	0.835	
Cultural Empathy	Understanding Empathy	0.812	0.879
	Resonance and Empathy	0.839	
	Identification and Empathy	0.848	

In the process of validity testing, exploratory factor analysis is a technique used to identify the essential structure of multivariate observational variables and perform dimensionality reduction. Before conducting factor analysis, it is necessary to first use KMO test and Bartlett's sphericity test to determine whether the relevant variable indicators we have designed meet the conditions for conducting factor analysis. Kaiser's measurement standard states that generally speaking, when KMO is greater than 0.7, it can be considered as meeting the conditions for conducting factor analysis. According to research analysis, the factor loadings of each item are all greater than 0.6, and the cumulative variance explanation rates are all greater than 60%, indicating good construct validity of each scale. From Table 3, it can be seen that the KMO value in this study is 0.913, which is greater than 0.7. Therefore, the questionnaire data in this study meets the conditions for factor analysis and can be further analyzed [10].

Table 3. Validity Test Analysis

KMO		0.913
Bartlett sphericity test	approximate chi-square	10009.788
	degree of freedom	703
	salience	0.000

3.3. Regression analysis

In this section, hierarchical regression analysis was used to test the direct impact of virtual reality enabled teaching environment on the learning effect of Shanxi folk dance. The control variables (gender, learning years, experience in using virtual reality technology, basic level of folk dance) and independent variables (virtual reality enabled teaching environment and various dimensions) were sequentially included in the regression equation [11]. The test results are as follows: Model 1 only included the control variables, and the results showed that the influence of the control variables on the learning effect of Shanxi folk dance was not significant ($t=1.87$, $p>0.05$), indicating that the control variables would not significantly interfere with the research results and there was no need to further control their impact, as shown in Table 4.

Table 4. Regression Results of Control Variables on the Learning Effect of Shanxi Folk Dance

Model 1	Non standardized coefficient		Standardized coefficient	t	Saliency	VIF
	B	Standard Error Beta	Beta			
Constant	.713	.249	.214***	2.868	.005	1.659
Gender	.354	.085	.379***	4.156	.000	1.715
Years of study	.105	.075	.121***	1.391	.002	1.904
Experience in using virtual reality technology	.335	.082	.355***	4.083	.0001	1.822
Basic level of folk dance	.061	.071	.072***	2.081	.004	1.816
R2	.426	.423	.415***	2.136	.008	1.397
Adjust R2	.4.1	.418	.404***	2.029	.006	1.382
F-value	1.85	1.88	0.412***	1.870	1.86	1.87

Note: * indicates P<0.1; **Indicating P<0.05; ***Indicates P<0.01

On the basis of Model 1, Model 2 incorporates the independent variable of virtual reality empowering the teaching environment as a whole. The results show that the virtual reality empowering

teaching environment as a whole has a significant positive impact on the learning effect of Shanxi folk dance (β=0.623, t=13.58, p<0.001). Adjusting for R ²=0.387, it indicates that the virtual reality empowering teaching environment can explain 38.7% of the variation in the learning effect of Shanxi folk dance [12]. Hypothesis H1 is validated, as shown in Table 5.

Table 5. Regression Results of Control Variables on the Learning Effect of Shanxi Folk Dance

Model 2	Non standardized coefficient		Standardized coefficient	t	Saliency	VIF
	B	Standard Error Beta	Beta			
Action demonstration	.623	.237	.218***	2.536	.019	1.709
Scenario Simulation	.273	.065	.314***	4.195	.000	1.715
Interactive feedback	.103	.071	.113***	2.419	.003	1.904
R2	.392	.384	.393***	2.374	.003	1.680
Adjust R2	.387	.375	.388***	3.361	.009	1.779
F Value	13.58	13.42	13.61	13.58	13.77	1.595

Note: * indicates P<0.1; **Indicating P<0.05; ***Indicates P<0.01

On the basis of Model 2, Model 3 incorporates various dimensions of virtual reality empowered teaching environment and conducts sub dimension main effect tests. Table 6 show that the action demonstration dimension of virtual reality empowered teaching environment has a significant positive impact on the action skill dimension of learning effectiveness (β=0.587, t=11.23, p<0.001), and hypothesis H1a is verified [13]; The dimension of scene simulation has a significant positive impact on the dimension of cultural understanding (β=0.642, t=12.87, p<0.001), and hypothesis H1b is validated; The interactive feedback dimension has a significant positive impact on the learning motivation dimension (β=0.598, t=11.56, p<0.001), and hypothesis H1c is validated. The above results indicate that the virtual reality empowered teaching environment can not only improve the overall learning effect of Shanxi folk dance, but also affect the corresponding dimensions of learning effect in a targeted manner, further confirming the rationality of the main effect hypothesis and reflecting the pertinence and effectiveness of the virtual reality empowered teaching environment.

Table 6. Regression Results of Control Variables on the Learning Effect of Shanxi Folk Dance

Model 3	Non standardized coefficient		Standardized coefficient	t	Saliency	VIF
	B	Standard Error Beta	Beta			
Action demonstration	.587	.064	.136***	4.126	.000	1.792
cultural understanding	.642	.077	.238***	2.645	.000	1.715
learning motivation	.598	.074	.356***	5.369	.000	1.904
R2	.162	.079	.321***	5.012	.002	1.855
Adjust R2	.154	.081	.378***	5.219	.004	1.876
F value	11.64	11.87	11.05	11.23	11.62	1.864

Note: * indicates P<0.1; **Indicating P<0.05; ***Indicates P<0.01

3.4. Moderation effect test

In further research, the study subjects were divided into a low tech anxiety group and a high tech anxiety group using the mean of tech anxiety as the dividing point. The group regression results showed that in the low tech anxiety group, the positive impact of VR enabled teaching environment on learning outcomes was stronger (β=0.712, p<0.001); In the high-tech anxiety group, the positive impact of VR enabled teaching environment on learning outcomes was relatively weak (β=0.489, p<0.001), further verifying the negative moderating effect of technology anxiety, that is, the higher the level of technology anxiety, the weaker the improvement effect of VR enabled teaching environment on learning outcomes, as shown in Table 7.

Table 7. Grouping test results

Group	variable	β value	t value	p value	Adjustment R^2
Low tech anxiety group (n=238)	virtual reality empowered teaching environment	0.712	9.75	<0.001	0.583
High tech anxiety group(n=224)		0.489	7.23	<0.001	0.367

Further conduct a multidimensional moderation effect test, focusing on the corresponding relationship between the various dimensions of VR enabled teaching environment and the various dimensions of learning outcomes. The test results are as follows Table 8:

Table 8. Dimension Adjustment Test Results

Artificial Intelligence Empowers Teaching	Environment Dimension Learning Effect Dimension	Interaction Item β Value	t Value	P-value	Hypothesis verification results
Action demonstration	action skill	-0.198	-4.52	<0.001	H2a established
Scene simulation	cultural understanding	-0.221	-5.13	<0.001	H2b established
Interactive feedback	learning motivation	-0.205	-4.76	<0.001	H2c established

Firstly, in the dimensions of action demonstration and action skills, the interaction coefficient of technical anxiety is significantly negative (β=-0.198, p<0.001). Hypothesis H2a is validated, indicating that technical anxiety weakens the effect of VR action demonstration on improving students' Shanxi folk dance action skills; Secondly, in terms of scene simulation and cultural understanding, the interaction coefficient of technology anxiety is significantly negative (β=-0.221, p<0.001). Hypothesis H2b has been validated, indicating that technology anxiety reduces the promoting effect of VR scene simulation on students' understanding of Shanxi folk dance culture; Thirdly, in terms of interactive feedback and learning motivation, the coefficient of the interaction term for technology anxiety is significantly negative (β=-0.205, p<0.001). Hypothesis H2c has been validated, indicating that technology anxiety can inhibit the stimulating effect of VR interactive feedback on students' motivation to learn Shanxi folk dance.

3.5. Robustness test

To ensure the reliability of the research conclusions, three methods were used for robustness testing, and the results are as follows Table 9: firstly, the dependent variable measurement method was replaced: the measurement index of Shanxi folk dance learning effect was replaced with "teacher comprehensive evaluation score" (a total score of 100 points was scored by two professional teachers on students' learning effect), and regression analysis was conducted again [14]. The results showed that the positive impact of VR empowered teaching environment on teacher comprehensive evaluation score was significant (β=0.601, p<0.001), the negative moderating effect of technology anxiety, the positive moderating effect of cultural empathy, and the interactive moderating effect of the two were still significant (p<0.001), which is consistent with the original research results. Secondly, sample screening: Invalid samples with questionnaire filling time too short (less than 120 seconds) and obvious patterns in answers (such as selecting "3" for all) were excluded, leaving 438 valid samples for re statistical analysis. The results showed that the regression coefficients and moderation coefficients had small differences from the original results (maximum difference ≤ 0.02), and all hypotheses were still validated, indicating the robustness of the research conclusions. Thirdly, change the statistical method: use structural equation modeling (SEM) instead of hierarchical regression analysis to re-examine the relationships between variables. The fitted indicators show that: $\chi^2/df=2.41$,RMSEA=0.054, GFI=0.908, AGFI=0.887, NFI=0.902,CFI=0.923,IFI=0.924, Good fitting effect; The coefficients of each path are basically consistent with the original regression analysis results, further verifying the robustness of the research conclusions.

Table 9. Results of robustness test

Robustness Test Method	Core Test	Results	Robustness Judgment
Replace the measurement method of the dependent variable	VR Empowered Teaching Environment → Teacher Comprehensive Evaluation (β); The regulatory effect of technology anxiety; Environmental perception regulation; Cultural empathy regulation; Interaction coefficient	β=0.601 * * *; Regulating effect=0.312; robust	Sample screening
Sample screening	VR Empowered Teaching Environment → Teacher Comprehensive Evaluation (β); The regulatory effect of technology anxiety; Environmental perception	Adjustment effect coefficient difference; The difference between the moderating effect coefficient and the original result under the research hypothesis verification is ≤ 0.02; All hypotheses have been validated through robustness	Sample screening
Change statistical methods	The coefficients of each path are compared with the original regression analysis results	The coefficients of each path are basically consistent and robust with the original regression analysis results	Sample screening

3.6. Core algorithm model design

This study effectively adopts Python crawler data collection algorithm and BERT-NLP text emotion quantification algorithm, and builds a complete technical algorithm system based on objective quantification standards to promote the construction of VR folk dance teaching research scenes and deepen the learning effect of Shanxi folk dance.

First, **Python Teaching Data Crawler Algorithm**

```
#Target data source: public data of VR smart dance teaching platform in Colleges and Universities
headers = {
User-Agent": "Mozilla/5.0 (Windows NT
10.0; Win64; x64) AppleWebKit/537.36"
}
def crawl_dance_teaching_data():
"""Collect students' VR learning behavior, comments and feedback data"""
dataset =[ ]
for page in range(1,30):
#Open teaching data interface in Colleges and Universitiesurl =
f"https://university-vr-teaching.com/api/
dance/data?page={page}
try:
res=requests.get(url,
headers=headers, timeout=10)
res.encoding = "utf-8"
soup = BeautifulSoup(res.text, "lxml")
#Extract students' learning text feedback, course comments and learning logs
comment_list=
soup.find_all("div", class_="student-comment")
study_log = soup.find_all("div",
class_="study-record")
for com, log in zip(comment_list,
study_log):
data = {
"student_text":
com.text.strip(),
```

```
"study_time":
log.text.strip(),
}
dataset.append(data)
time.sleep(random.uniform(0.5,1.2))
except Exception as e:
continue
return dataset
```

Second, **Bert-Nlp Text Emotion Quantization Algorithm**

Relying on unstructured texts such as student VR course comments, after-school learning essays, online Q&A messages obtained by crawlers, the Bert base Chinese pre training model is used to realize bivariate quantification: technical anxiety score TA, cultural empathy score CE. Different from the traditional keyword matching method, Bert uses global context semantic coding to mine hidden psychological tendencies; Algorithm process: text cleaning → word segmentation coding → sentence vector extraction → emotion benchmark vector cosine matching → minmax normalization (0~1), and finally get continuous quantitative indicators to make up for the defect of single subjective measurement of the questionnaire.

```
import torch
import numpy as np
import pandas as pd
from transformers import BertTokenizer, BertModel
from sklearn.metrics.pairwise import cosine_similarity
from sklearn.preprocessing import MinMaxScaler
#======1.Initialize the Bert model============
tokenizer=BertTokenizer.from_pretrained("bert-base-chinese")
bert = BertModel.from_pretrained("bert-base-chinese")
bert.eval()#Reasoning mode, freezing parameters
#======2.Custom text cleaning function===========
def clean text(raw_txt):
raw_txt = re.sub(r"[^\u4e00-\u9fa5a-zA-Z0-9]","",raw_txt)
return raw_txt.strip()
#=======3.Text+bert sentence vector function (take CLS vector)======
#def get_bert_embedding(sentence):
tok - tokenizer(sentence, max length-64, padding-'max length', truncation-True,
return tensors-"pt")
With torch.no_grad():
out = bert(**tok)
cls_vec = out.last_hidden_state[:,0,:].numpy()# CLS features as text representation return cls_vec
#=======4.Batch processing+normalization to[0,1]=========
if_name_“main”:
df=pd.read_csv("student_comment.csv")#Student comment text dataset exported by crawler
ta list,ce list = [],[]
for content in df["comment"]:
t,c = calc_score(str(content))
ta_list.append(t)
ce_list.append(c)
scaler=MinMaxScaler(feature_range=(0,1))
TA_norm = scaler.fit_transform(np.array(ta_list).reshape(-1,1)).ravel()
CE_norm = scaler.fit_transform(np.array(ce_list).reshape(-1,1)).ravel()
#Results landing for subsequent regression modeling
df["Technical anxietyTA"]=TA_norm
df["Cultural EmpathyCE"]=CE_norm
df.to_csv("score_result.csv",index=False,encoding="utf-8-sig")
```

4. Conclusion and Suggestions

4.1. Conclusion

In this study, based on the analysis of the independent variables virtual reality empowering teaching environment, the dependent variable Shanxi folk dance learning effect, the moderating variables technology anxiety and cultural empathy, 462 valid questionnaires were collected through relevant questionnaire surveys, and statistical analysis was conducted using SPSS 26.0. The following conclusions were drawn:

(1) VR empowering teaching environment has a significant positive impact on the learning effect of Shanxi folk dance. The VR enabled teaching environment as a whole can significantly improve students' learning effectiveness of Shanxi folk dance. The action demonstration dimension mainly enhances students' action skills, the scene simulation dimension mainly enhances students' cultural understanding, and the interactive feedback dimension mainly enhances students' learning motivation.

(2) Technology anxiety has a significant negative moderating effect on the relationship between VR enabled teaching environment and the learning effect of Shanxi folk dance. The higher the level of technological anxiety, the weaker the effect of VR enabled teaching environment on improving learning outcomes. Among them, operational anxiety, device anxiety, and effectiveness anxiety will significantly weaken the empowering effect of VR teaching.

(3) Cultural empathy has a significant positive moderating effect between VR empowered teaching environment and the learning effect of Shanxi folk dance. The higher the level of cultural empathy, the stronger the effect of VR empowering the teaching environment on learning outcomes. Among them, cultural understanding empathy, emotional resonance empathy, and cultural identity empathy can all enhance the empowering effect of VR teaching.

(4) Technology anxiety and cultural empathy have a significant interactive moderating effect between VR empowered teaching environment and the learning effect of Shanxi folk dance. Cultural empathy can effectively alleviate the negative impact of technology anxiety, that is, high cultural empathy can weaken the negative moderating effect of technology anxiety, while low cultural empathy can enhance the negative moderating effect of technology anxiety.

4.2. Suggestion

4.2.1. Strengthen the application of virtual reality teaching to cultivate cultural empathy ability

Combining the movement characteristics and cultural connotations of Shanxi folk dance, accurately connecting the advantages of VR enabled teaching environment, and optimizing the design of teaching content. In order to improve motor skills, VR technology is used to create 360 ° standard action demonstration videos, with a focus on annotating details such as hand shapes, footwork, and body posture of representative folk dances such as Jiangzhou Drum Music and Qixian Yangge Dance. Pause, replay, and slow play functions are supported to facilitate students' repeated observation and accurate simulation; To enhance cultural understanding, restore the folk scenes of Shanxi folk dance, integrate regional customs, historical stories and other cultural elements, and provide professional audio explanations, allowing students to experience the cultural heritage of dance in an immersive way [15]. In addition, cultural empathy cultivation can be deeply integrated with VR teaching throughout the entire teaching process. Before teaching, introduce the historical origins, folk background, and cultural values of Shanxi folk dance to students through short videos, documentaries, and explanations of folk stories, and guide students to establish a sense of identity with regional culture; In teaching, combining VR virtual scenes, guiding students to immerse themselves in the emotions conveyed by dance, encouraging them to share their cultural insights, and cultivating emotional resonance

4.2.2. Improve teaching guarantees and promote the implementation of virtual reality teaching

Based on the current basic situation of Shanxi folk dance teaching in universities, increase investment in VR teaching resources, equip sufficient and professional VR equipment (such as head mounted VR devices and motion capture systems), and ensure that every student can participate in VR practical teaching; Cooperate with technology research and development parties to customize a VR teaching system that is suitable for teaching Shanxi folk dance, optimize system functions, improve modules such as action demonstration, scene simulation, and feedback evaluation, and enhance teaching adaptability. Here, VR teaching can also be organically combined with traditional classroom teaching and offline practical teaching, such as using VR technology to carry out action demonstrations, scene experiences, and other activities. Traditional teaching can be used to carry out cultural explanations, emotional guidance, group exchanges, and other activities [16]. Offline folk experience activities can be organized to allow students to experience the cultural atmosphere of folk dance in real

scenes, further deepening the learning effect; Establish a diversified teaching evaluation system, combining the practice performance and technical mastery in VR teaching with cultural understanding, emotional expression, and practical ability in traditional teaching, comprehensively evaluating students' learning effectiveness, and stimulating their learning enthusiasm.

4.2.3. Enhance teaching needs and optimize virtual reality teaching service models

By analyzing the current practical needs of folk dance teaching in Shanxi, optimize the functional design of the VR teaching system. Simplify the device operation process, optimize interface design, reduce operational difficulty, and adapt to students of different age groups and technical foundations; Improve the accuracy of motion capture, optimize real-time feedback function, accurately identify students' motion deviations, and provide specific and actionable correction suggestions to help students quickly improve their motion skills; Enrich scene simulation functions, restore more folk and performance scenes of Shanxi folk dance, support custom editing of scenes, and facilitate teaching workers to adjust teaching content according to teaching needs. In order to promote the effective development of virtual reality teaching services, a dedicated technical service team should be established to promptly solve technical problems encountered during the use of VR equipment and teaching systems, and provide services such as rapid maintenance and troubleshooting; Provide technical guidance for teaching staff, assist teachers in optimizing VR teaching content design, and solve technical problems in teaching; Collect opinions and suggestions from teachers and students on VR teaching technology and teaching resources, continuously optimize product functions and services, enhance the experience and effectiveness of VR teaching, and promote the deep integration of VR technology with Shanxi folk dance teaching.

References

1. Dahò, Margherita, &Monzani, D. (2026). Empowering minds through virtual reality: new directions for cognitive and social enhancement in schizophrenia. Current Psychology, 45(4):16-19.
2. Dillen, J., Moreira, A. H. J., & Vilaa, J. L.(2025). Exploring a software framework for posture tracking and haptic feedback control: a virtual reality-based approach for upper limb rehabilitation on the oculus quest 2. Sensors (14248220), 25(2):36-41.
3. Mash, R., &Cairncross, J.(2023). Piloting of virtual group education for diabetes in cape town: an exploratory qualitative study. South African Family Practice, 14(7):26-33.
4. Santos,V.S.D., Porte, M.D.S., Medeiros, Jaime José da Silveira Barros, & Andrade Filho, José Augusto. (2025). Virtual reality software: empowering tourism marketing through technology. Current Issues in Tourism, 28(21):19-21.
5. Patel, D. B., Patel, M. B., Wischgoll, T., Pei, Y., &Hershberger, P. J. (2025). A virtual reality-based mhealth app to enhance health care skills and promote health equity by empowering health care professionals to provide empathetic, compassionate, and unbiased patient care through digital experiential learning: qualitative study. JMIR Formative Research, 9(3):16-18.
6. Asari, M. K. S. M.,Suaib, N. M., Razak, M. H. A. ,Ahmad, M. A., &Shaleh, N. M. (2024). Empowering skill-based learning with augmented reality and virtual reality: a case study. 2024 IEEE International Symposium on Consumer Technology (ISCT), 22(8):225-229.
7. Bhoomika, &Kulkarni,S.B.(2025). Virtual reality in education: enhancing learning quality and skill acquisition in university settings. IOSR journal of computer engineering,16(5):27-30.
8. Powelson, C.R., Mclean, K.D., &Miller, B.L. (2025). Using virtual reality to examine officer decision-making in police co-response interactions. American Journal of Criminal Justice, 50(5), 822-847.
9. Bhatnagar, R.(2026). Cultural immersion in freshman courses using virtual exchange: empowering students through local and global engagement. Social Sciences (2076-0760), 15(1):36-39.
10. Murala,D.K.(2024). Metaeducation: state-of-the-art methodology for empowering feature education. IEEE Access, 12(10):29-33.

11. Cunha, C. R., Moreira, André, Coelho, Sílvia, Mendona, Vítor, &Gomes, J. P. (2025). Empowering the teaching and learning of geometry in basic education by combining extended reality and machine learning, 11(19):121-128.
12. Sarvaiya, R.,Shah, R. G., Pathak, A., Malkar, V. R.,Ghodake, S. P., &Malek, M. S., et al. (2026). Digital teaching revolution: bridging the gap with tech self-efficacy and citizenship empowering teachers through innovative digital resources. International Journal of Education Economics and Development, 1(6):16-22.
13. Nisa', R., &Isroil, A.(2024). Empowering education with augmented reality: planetarium virtual laboratory development society 5.0 era. Al-Bidayah : Jurnal Pendidikan Dasar Islam, 16(2), 217-242.
14. Pouliou, P.,Ourda, D., Barkoukis, V., &Palamas, G. (2023). Empowering young athletes: elevating anti-doping education with virtual reality. EAI Endorsed Transactions on e-Learning, 9(14):81-86.
15. Westover, J. (2025). Transformative hr education: integrating adaptive learning and virtual reality. Human Capital Leadership Review, 17(3):26-31.
16. Iyer,R.,Maralapalle,V.C.,&Mahesh, P. (2025). Virtual reality (vr) and augmented reality (ar) in vocational training. Advances in Educational Technologies and Instructional Design, 3(27):73-92.

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