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AI Empowered Innovation in Cross-Cultural Education in Universities Construction of a Multimodal Data-Driven Cultural Comparison Teaching System and Research on its International Communication Effectiveness

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ABSTRACT Under the dual drive of globalization and digital education strategies, cross-cultural education in universities is shifting toward integrated cultivation of knowledge construction and international communication ability. To address problems such as single cultural samples, insufficient interaction, neglected individual differences, vague effectiveness evaluation, and weak international communication outcomes, this study integrates artificial intelligence, multimodal data perception, and cultural comparison teaching to construct an AI-empowered cross-cultural education system. The system includes a cultural knowledge graph module, multimodal emotion and behavior perception module, adaptive learning path module, cross-cultural scenario simulation and dialogue module, and international communication effectiveness evaluation module. It forms a closed-loop process of precise perception, adaptive teaching, immersive simulation, and quantitative evaluation. Empirical results show that the system improves students' comprehensive international communication effectiveness score by 28.3% and increases teaching satisfaction by 32.7%. The study provides a replicable framework for cross-cultural education reform and supports the transformation from teaching cultivation to communication competence generation.

INDEX TERMS artificial intelligence, cross-cultural education, multimodal data, cultural comparison teaching, international communication

I. INTRODUCTION

A. RESEARCH BACKGROUND

WITH the deepening of globalization and increasingly frequent international exchanges, cross-cultural competence has become a core competency for college students and a vital talent foundation for enhancing national cultural soft power through the global dissemination of technical heritage in smart weaving and high-performance fiber artistry. This proficiency enables future professionals to effectively lead the international discourse on innovative functional and advanced material science, strengthening both global communication capabilities and industrial influence. As the main battlefield for cultivating cross-cultural talents, universities undertake the important mission of enhancing students' cultural understanding, cultural comparison, cultural dialogue, and cultural dissemination abilities. In recent years, China has vigorously promoted the digitalization strategy of education and the construction of international communication capabilities, clearly proposing "innovative cross-cultural education models in universities" and "using digital technology to enhance the effectiveness of international communication of Chinese culture", pointing out the direction for cross-cultural education reform [1,2].

However, there are currently five major practical challenges in cross-cultural education in domestic universities:

Firstly, the teaching content is homogenized, focusing mainly on language knowledge points, with insufficient cultural depth, weak value guidance and critical thinking cultivation, making it difficult to support students in forming a complete cultural cognitive framework;

Secondly, the teaching methods have become more traditional, with classroom lectures as the main focus. Immersive, experiential, and interactive teaching methods are insufficient, and students passively receive knowledge, lacking cross-cultural dialogue and conflict response training in real-life scenarios;

Thirdly, individual differences are ignored, and adaptive teaching services cannot be provided based on students' language proficiency, cultural background, cognitive style, and emotional attitude. The "one size fits all" model leads to polarized learning outcomes;

Fourthly, the evaluation of effectiveness is blurred, with exams and assignments as the main focus, lacking quantitative assessments of core competencies such as cross-cultural empathy, conflict response, and communication willingness. The evaluation results are difficult to use for precise teaching improvement; Fifth, there is a disconnect between international communication, with teaching and international communication practices separated. Students lack training in real-life public opinion scenarios, making it difficult for them to translate cultural understanding into effective communication behaviors and meet the needs of national cultural communication strategies [3,4].

B. RESEARCH SIGNIFICANCE

C. THEORETICAL SIGNIFICANCE

(1) This research constructs an integrated theoretical framework encompassing AI, cross-cultural education, and multimodal data to enrich the study of educational technology and international communication within the technical heritage of smart weaving and high-performance fiber artistry. By bridging the gap between humanities and artificial intelligence, the framework provides a robust foundation for the global dissemination of advanced functional innovations and sustainable material science;

(2) Propose a multimodal data-driven cultural comparative teaching theory, revealing how AI can enhance cultural cognition and empathy mechanisms through data perception, emotion computing, and knowledge graph, and improve the technology empowerment theory of cross-cultural education;

(3) Establish a theory for evaluating the effectiveness of cross-cultural education international communication, clarify the path and rules for the transformation of teaching effectiveness to communication effectiveness, and construct a comprehensive theoretical model of "teaching cultivation ability generation international communication";

(4) Expand the application theory of artificial intelligence in humanities and social sciences education, provide new paradigms for smart education and digital teaching, and promote the extension of educational technology theory towards the cultivation of humanistic literacy.

D. PRACTICAL SIGNIFICANCE

(1) Provide a set of AI cross-cultural teaching systems that can be implemented, expanded, and evaluated for universities, significantly improving classroom interaction, immersion, and teaching efficiency, and solving traditional teaching pain points;

(2) Implementing personalized teaching, dynamically adjusting teaching content, difficulty, pace, and strategies based on students' multimodal behavior data, narrowing individual differences, and improving overall learning effectiveness;

(3) Through realistic cross-cultural conflict simulation and international communication training, we aim to enhance students' practical abilities in telling Chinese stories, engaging in rational dialogue, and resisting cultural biases, in order to serve the international communication strategy of Chinese culture;

(4) Forming quantifiable, traceable, and comparable teaching effectiveness data, providing scientific basis for curriculum quality improvement, professional evaluation, and teaching reform, and promoting the high-quality development of cross-cultural education in universities;

(5) To provide intelligent tools for international Chinese education, international student education, and cultural exchanges between China and foreign countries, and to enhance the accuracy and effectiveness of the dissemination of Chinese culture to the outside world.

E. CURRENT RESEARCH STATUS AT HOME AND ABROAD

The research on international communication effectiveness focuses on media communication, national image, discourse strategy, and other aspects, forming classic theories such as the 5W communication model, agenda setting theory, and framework analysis. However, there is a serious lack of research from the perspective of education, with college students as the main body of communication, teaching systems as the path, and efficiency improvement as the goal. A "teaching ability communication" interconnected path has not yet been formed, and there is a lack of empirical research directly linking cross-cultural education with international communication efficiency [5,6].

F. RESEARCH IDEAS, METHODS, AND INNOVATIVE POINTS

G. RESEARCH APPROACH

Guided by the problem, follow the complete technical route of "theoretical construction → system design → technical implementation → empirical verification → conclusion and recommendation":

1. Sort out the current difficulties and theoretical foundations of cross-cultural education in universities, define core concepts and internal mechanisms;
2. Build the overall architecture and core functional modules of an AI multimodal cross-cultural teaching system;
3. Design a multimodal data acquisition, processing, analysis, and teaching intervention mechanism;
4. Establish a four-dimensional international communication effectiveness evaluation index system;

5. Select college students to conduct comparative teaching experiments and test the effectiveness of the system;

6. Propose system optimization strategies and promotion paths.

H. RESEARCH METHODS

(1) Literature research method: Systematically review theories in cross-cultural education, AI education, multimodal learning, international communication, and other fields to grasp the forefront and shortcomings of research;

(2) System design method: Construct the teaching system architecture, functional modules, data flow, algorithm logic, and complete engineering design;

(3) Multimodal data analysis method: Collecting multidimensional data such as text, speech, facial expressions, and behavior for fusion modeling and state recognition;

(4) Empirical experimental method: Select college students to conduct a 16-week controlled teaching experiment, and verify the effectiveness of the system through quantitative data and qualitative analysis;

(5) Questionnaire survey and interview method: Obtain qualitative data such as students' learning experience, cultural attitudes, and communication willingness, and supplement quantitative results.

I. INNOVATION POINTS

(1) Theoretical innovation: For the first time, an integrated theoretical framework of "AI empowerment multimodal perception cultural comparison international communication effectiveness" has been constructed, connecting the logical chain between the education and communication ends;

(2) System innovation: Develop an intelligent teaching system that integrates cultural knowledge graph, adaptive learning, emotional computing, conflict simulation, and effectiveness evaluation, achieving closed-loop optimization of the entire process;

(3) Method innovation: Adopting multimodal data to achieve a comprehensive quantitative evaluation of cross-cultural cognition, empathy, behavior, and communication willingness, breaking through the sub jective limitations of traditional humanistic education evaluation;

(4) Path innovation: Propose a transformation path of "teaching cultivation ability generation international communication", providing a replicable practical paradigm for universities to serve the national cultural communication strategy.

Theoretical innovation: For the first time, a clear and logical integrated framework is constructed: AI empowerment provides technical support; multimodal perception achieves comprehensive state recognition; cultural comparison teaching promotes deep understanding; and the whole process finally enhances international communication effectiveness.

II. CORE CONCEPTS AND THEORETICAL FOUNDATIONS

A. DEFINITION OF CORE CONCEPTS

B. AI EMPOWERED CROSS CULTURAL EDUCATION

Cross cultural education empowered by AI refers to a new teaching model that is personalized, immersive, data-driven, and quantifiable, built around the five core competency goals of cultural cognition, cultural comparison, cultural empathy, cross-cultural communication, and cultural dissemination, supported by digital technologies such as artificial intelligence, multimodal perception, and big data analysis. Compared with traditional cross-cultural education, its core features are reflected in four aspects [7]:

Technological empowerment: Through AI, intelligent organization of teaching content, precise perception of learning status, dynamic adaptation of teaching strategies, and quantitative evaluation of learning outcomes can be achieved;

Mode innovation: shifting from "one-way teaching" to "immersive interaction, situational exercises, and personalized tutoring", strengthening students' subjectivity and practical abilities;

Data driven: Based on multimodal learning behavior data, achieve the transformation of teaching decision-making from "experience judgment" to "scientific evaluation";

Goal upgrade: Upgrade from "language+cultural knowledge transmission" to "cross-cultural competence+in ternational communication effectiveness" integrated training, serving the national cultural communication strategy.

The essence of cross-cultural education empowered by AI is to use technology to solve the pain points of traditional teaching, achieve "teaching according to aptitude, teaching based on learning, and integrating learning with application", which is a typical paradigm of deep integration of educational digitization and humanistic literacy education [8-10].

C. MULTIMODAL DATA-DRIVEN TEACHING

Multimodal data-driven teaching refers to an intelligent teaching paradigm that collects, integrates, and analyzes multidimensional heterogeneous data generated by learners during the learning process, such as text, speech, facial expressions, interactive behaviors, response time, and learning platform logs, to construct a lightweight learning state portrait of learners, achieve accurate judgment of learning status, cognitive level, emotional attitude, and behavioral tendency, and dynamically adjust teaching content, difficulty, rhythm, and strategies. The system adopts a lightweight, low-cost, universal sensing solution without relying on professional sensors, and is fully compatible with conventional hardware conditions in university classrooms and online learning environments.

The core logic is a closed loop of "perception understanding intervention optimization":

1. Perception layer: Collecting multimodal raw data through cameras, microphones, sensors, platform logs, etc;

2. Understanding layer: Extracting learning state features through algorithms such as emotion calculation, cognitive load recognition, and intention understanding;

3. Intervention layer: Based on the portrait results, push personalized learning resources, adjust teaching difficulty, and provide emotional feedback;

4. Optimization layer: Through long-term data accumulation, iterative models and strategies, continuously improve teaching accuracy and effectiveness.

Multimodal data-driven teaching breaks through the limitations of traditional "single score evaluation" and can comprehensively reflect the true state of learners, providing a scientific evaluation and precise intervention technical foundation for cross-cultural education, which is highly dependent on emotions, attitudes, and behavioral performance in humanities courses.

D. CULTURAL COMPARISON TEACHING PARADIGM

The cultural comparison teaching paradigm is a teaching model that uses comparative analysis as its core methodology to systematically compare the values, thinking patterns, behavioral norms, discourse logic, aesthetic habits, and communication strategies of different cultural systems, cultivating students' cultural selfawareness, cultural understanding, critical thinking, rational dialogue, and cultural dissemination abilities. Its core connotations include:

Comparative objects: covering multiple dimensions such as Chinese and Western cultures, different regional cultures, mainstream cultures, and subcultures;

Comparative dimensions: including values (individualism/collectivism), ways of thinking (analytical/holistic), communication norms (direct/indirect), discourse systems (formal/informal), etc;

Teaching objective: To go beyond the description of cultural differences and cultivate students' higher-order abilities of "understanding differences, respecting differences, rational dialogue, and effective communication";

Teaching methods: Case comparison, situational simulation, group debate, virtual dialogue, real-life scenario exercises, etc.

Cultural comparison teaching is the core method of cross-cultural education and the fundamental path for cultivating international communication skills. It can help students establish a cognitive chain of "cultural consciousness cultural confidence cultural dialogue".

E. INTERNATIONAL COMMUNICATION EFFICIENCY

International communication effectiveness refers to the comprehensive effect of young communication subjects with college students as the core, accurately interpreting cultural connotations, rationally expressing cultural positions, effectively conveying cultural values, and gaining recognition and positive feedback from target audiences in cross-cultural contexts. Its core is to measure the degree of transformation of "cultural knowledge cross-cultural competence actual dissemination behavior dissemination effect" [11, 12]. This article breaks down the effectiveness of international communication into five progressive levels:

1. Cognitive level: The audience's awareness and understanding of Chinese culture;

2. Emotional level: audience's favorability, tolerance, and empathy towards Chinese culture;

3. Attitude level: Audience's level of identification and trust in Chinese culture;

4. Behavioral level: The willingness and behavior of the audience to actively spread, share, and practice Chinese culture;

5. Effectiveness level: coverage, influence, breadth, and depth of dissemination of content.

The effectiveness of international communication is the core evaluation objective of this article, and it is also the ultimate embodiment of the national strategy of cross-cultural education services in universities [13].

F. THEORETICAL BASIS

G. THEORY OF CROSS CULTURAL COMMUNICATION COMPETENCE

The theory of intercultural communication competence is the core competency objective foundation of the teaching system in this article. The classic model divides it into five interrelated dimensions: cultural knowledge, cultural attitude, empathy, communicative competence, and conflict response ability

Cultural knowledge dimension: refers to the learners' mastery of objective knowledge such as the history, values, social norms, language habits, etc. of different cultures, which is the cognitive foundation of cross-cultural communication;

Cultural attitude dimension: refers to learners' openness, respect, tolerance towards different cultures, as well as their sense of identity and confidence in their own culture, which is an emotional prerequisite for cross-cultural communication;

Empathy dimension: refers to the ability of learners to understand the emotions, needs, and behavioral logic of the other party from their cultural perspective, which is the emotional bond of cross-cultural communication; The dimension of communicative competence refers to the language and nonverbal communication abilities of learners to accurately express, effectively listen, and respond reasonably in cross-cultural contexts, which is the core of cross-cultural communication behavior;

The dimension of conflict response ability refers to the ability of learners to rationally analyze, effectively communicate, and properly resolve misunderstandings, contradictions, and conflicts caused by cultural differences. It is a high-level manifestation of cross-cultural communication [14,15].

This theory provides a direct basis for the functional design, ability development objectives, and evaluation index system of the teaching system in this article, ensuring that the teaching content and evaluation direction focus on the real cross-cultural communication needs [16].

H. CONSTRUCTIVIST LEARNING THEORY

Constructivist Learning Theory is specifically adapted to cross-cultural education in this study. It supports the creation of immersive cross-cultural scenarios, virtual dialogues, cultural conflict simulations, and roleplaying tasks, enabling learners to actively construct multi-perspective cultural cognition rather than passively receive knowledge. It directly corresponds to the situational simulation module in the system design.The core viewpoints include:

Initiative: Learners are the main body of knowledge construction, rather than passive recipients;

Situational: Knowledge learning needs to be placed in real or simulated problem contexts in order to achieve meaning construction;

Sociality: Learning is accomplished through social activities such as dialogue, collaboration, and interaction;

Personalization: Learners have different experiences and cognitive styles, resulting in differences in knowledge construction paths and outcomes.

AI technology provides key support for the implementation of constructivist learning theory in cross-cultural education:

Immersive scenario: By using technologies such as virtual simulation and digital human dialogue, a real cross-cultural communication context is constructed to provide an environmental foundation for knowledge construction;

Interactive simulation: Through interactive forms such as group collaboration, role-playing, and debate, reinforce the sociality of learning;

Personalized support: Through an adaptive learning system, differentiated resources and guidance are provided to students with different cognitive levels and learning styles, adapting to personalized construction paths [17].

I. ADAPTIVE LEARNING THEORY

The theory of adaptive learning originates from the idea of individualized teaching and cognitive load theory. The core viewpoint is that teaching content, difficulty, pace, and strategies need to be dynamically adjusted according to the individual characteristics of learners to achieve optimal learning outcomes. Individual char acteristics of learners include:

Cognitive characteristics: knowledge foundation, cognitive level, learning ability, cognitive style;

Emotional characteristics: learning interest, motivation, emotional state, self-efficacy;

Behavioral characteristics: learning progress, engagement, interaction habits, task completion status;

Target characteristics: learning objectives, career planning, and development needs.

The implementation path of adaptive learning is a closed loop of "learner profile learning diagnosis resource recommendation strategy adjustment effect feedback". In this article's AI cross-cultural teaching system, the theory of adaptive learning is specifically reflected as follows:

Constructing panoramic portraits of learners based on multimodal data;

Diagnose students' shortcomings in cultural knowledge, empathy, communication skills, and other aspects; Dynamically recommend suitable learning content, cases, exercises, and situational tasks;

Adjust teaching difficulty and pace in real-time based on learning progress and status changes;

Formulate personalized learning reports and improvement suggestions [18-20].

Adaptive Learning Theory is applied to address prominent individual differences in cross-cultural classes, including differences in language proficiency, cultural background, cognitive style, and emotional attitude. It provides personalized resource allocation and dynamic path adjustment, and directly supports the adaptive learning path module in the system.

J. EMOTIONAL COMPUTING AND MULTIMODAL PERCEPTION THEORY

The theory of affective computing was proposed by Picard in 1995, with the core of enabling computers to recognize, understand, express, and respond to human emotions, achieving emotional interaction between humans and machines. The multimodal perception theory emphasizes the integration of multiple sensory modalities data (visual, auditory, textual, etc.) to more comprehensively and accurately perceive human states.

The core values of affective computing and multimodal perception theory in educational settings are:

Emotional state recognition: By using facial expressions, voice tone, text semantics, etc., students' positive/ negative emotions, focus/distraction states, confusion/pleasure feelings can be determined;

Cognitive load assessment: Determine the difficulty adaptation and cognitive pressure of students' current learning content through eye movement trajectory, reaction time, interaction frequency, etc;

Participation analysis: Evaluate students' classroom participation and learning engagement through posture, clicking behavior, speaking frequency, etc;

Precision teaching intervention: Based on the results of state recognition, personalized interventions such as emotional encouragement, difficulty adjustment, and attention guidance are provided.

This article applies this theory to cross-cultural teaching, focusing on addressing humanistic indicators such as students' cultural attitudes, empathy levels, and learning motivation that are difficult to measure through traditional methods, providing objective data support for teaching intervention and effectiveness evaluation.

K. INTERNATIONAL COMMUNICATION EFFICIENCY THEORY

The theory of international communication effectiveness originates from the 5W model of communication studies

(Laswell's formula), emphasizing that communication is a process of interaction among five elements: communication subject, communication content, communication channel, communication audience, and communication effect. Communication effectiveness is the comprehensive result of the synergistic effect of various elements.

The core viewpoints include:

Communication subject: Their identity, credibility, and cultural literacy directly affect the effectiveness of communication;

Communication content: The authenticity, targeting, narrative, and value orientation of the content determine the attractiveness and persuasiveness of the communication;

Communication channels: The communication efficiency and audience coverage of different channels (social media, offline conversations, academic exchanges, etc.) vary;

Target audience: The cultural background, cognitive level, emotional attitude, and information needs of the target audience are key variables for the effectiveness of communication;

Communication effectiveness: divided into four levels: cognition, emotion, attitude, and behavior, it is the ultimate manifestation of communication effectiveness.

This theory provides the core framework for the evaluation system of international communication effectiveness in this article:

Communication subject: corresponding to students' cross-cultural competence and communication literacy;

Communication content: cultural knowledge and discourse strategies mastered in cultural comparison teaching;

Communication channels: corresponding to simulated dialogues, social media, speeches, and other scenarios in teaching;

Communication audience: corresponding to virtual cross-cultural dialogue objects in teaching;

Communication effectiveness: Corresponding to the four-dimensional indicators of cognition, empathy, ability, and communication in the evaluation system of this article.

L. THE INTRINSIC MECHANISM OF AI EMPOWERING CROSS-CULTURAL EDUCATION

AI technology systematically reconstructs traditional cross-cultural education from four core levels: content layer, experience layer, teaching layer, and evaluation layer, forming an internal logic of "technology empowerment mode innovation efficiency improvement":

M. CONTENT LAYER: FROM FRAGMENTATION TO STRUCTURING, ACHIEVE THE CORRELATION AND VISUAL PRESENTATION OF CULTURAL KNOWLEDGE

Traditional cross-cultural education content is mostly fragmented knowledge points, lacking systematicity and relevance. AI uses cultural knowledge graph technology to structurally model dispersed cultural concepts, historical events, values, communication norms, etc., constructing a knowledge network of "concept relationship instance":

Realize visual retrieval and navigation of cultural content, helping students quickly establish cultural cognitive frameworks; Support cross-cultural comparison queries, visually presenting the differences between Chinese and Western cultures in terms of values, ways of thinking, and other dimensions;

Realize dynamic updating and expansion of knowledge, timely integrate new cultural phenomena and dissemination cases;

Provide content recommendation basis for adaptive learning and accurately match students' knowledge gaps.

N. EXPERIENCE LAYER: FROM LECTURE BASED TO IMMERSIVE, ENHANCE STUDENTS' PARTICIPATION AND PRACTICAL ABILITIES

Traditional cross-cultural education mainly relies on classroom lectures, and students lack real practical opportunities. AI reconstructs the learning experience through immersive simulation, virtual digital human dialogue, situational exercises, and other technologies Constructing authentic cross-cultural communication scenarios (such as business negotiations, academic exchanges, public opinion dialogues, etc.) to enable students to 'learn by doing';

Through virtual human interaction, achieve 24-hour uninterrupted cross-cultural dialogue practice, breaking through time and space limitations;

Through role-playing and conflict simulation, students can practice dealing with cultural misunderstandings and conflicts in a safe environment, enhancing their practical skills;

Enhance the fun and immersion of learning, stimulate students' learning motivation and participation.

O. TEACHING LAYER: FROM STANDARDIZATION TO PRECISION, ACHIEVING INDIVIDUALIZED TEACHING AND PERSONALIZED CULTIVATION

Traditional cross-cultural education adopts a large class teaching model of "unified pace and unified content", which is difficult to adapt to individual differences among students. AI achieves precise teaching through multimodal perception and adaptive learning technology:

Constructing a panoramic portrait of learners based on multimodal data, accurately identifying students' characteristics in knowledge, abilities, emotions, behaviors, and other aspects;

Dynamically adjust the difficulty level, learning path, and practice tasks of teaching content to achieve "teaching according to students' aptitude";

Real-time perception of students' emotional state and cognitive load, providing timely encouragement, guidance, or difficulty adjustment to avoid learning fatigue and frustration;

Provide teaching decision support for teachers, help them focus on key students and issues, and improve classroom efficiency.

P. EVALUATION LAYER: FROM EXPERIENTIAL TO DATA-DRIVEN, ACHIEVE QUANTIFIABLE PERFORMANCE EVALUATION THROUGHOUT THE ENTIRE PROCESS

Traditional cross-cultural education evaluation mainly relies on exams, assignments, and subjective comments, which makes it difficult to objectively reflect students' cross-cultural abilities and international communication effectiveness. AI achieves quantifiable evaluation of the entire process through multimodal data fusion analysis technology Collect data on the entire learning process (classroom performance, homework, dialogue, simulation tasks, etc.) to avoid the "one exam determines lifelong" approach;

Quantitatively measuring cultural empathy, cross-cultural attitudes, and willingness to spread, which are traditionally difficult to evaluate humanistic indicators;

Constructing a multidimensional performance evaluation model to achieve a transition from "empirical judgment" to "scientific evaluation";

Generate personalized evaluation reports and improvement suggestions to provide data support for student growth and teaching optimization.

III. ANALYSIS OF THE CURRENT CHALLENGES AND AI EMPOWERMENT NEEDS IN CROSS CULTURAL EDUCATION IN HIGHER EDUCATION INSTITUTIONS

A. TEACHING CONTENT LEVEL: INSUFFICIENT CULTURAL DEPTH AND WEAK COMPARABILITY

The current cross-cultural teaching content in universities mainly focuses on language knowledge points and basic cultural knowledge, and there are three major problems:

Single cultural sample: mostly focused on mainstream Western culture, with insufficient coverage of multiculturalism, subcultures, and emerging cultural phenomena;

Insufficient depth of comparison: stuck at the level of "cultural differences description", lacking in-depth comparison of values, thinking patterns, and discourse logic;

Weak value guidance: Insufficient integration of cultural confidence, rational dialogue, and critical thinking cultivation, making it difficult to support the generation of international communication capabilities. This content system leads to students being "aware of the situation but unaware of the reasons behind it", making it difficult to form a complete cultural cognitive framework and cope with complex cross-cultural scenarios and international public opinion challenges.

B. TEACHING METHOD LEVEL: INSUFFICIENT INTERACTIVE IMMERSION AND WEAK STUDENT SUBJECTIVITY

Traditional teaching mainly relies on "teacher lectures+PPT presentations", which has three major limitations:

One-way indoctrination is dominant: students passively receive knowledge and lack opportunities for active thinking and practice;

Lack of scene experience: Lack of authentic cross-cultural communication scenes, making it difficult for students to transform knowledge into abilities;

The interactive form is single: mostly classroom questioning and group discussions, with low participation and difficulty in covering all students.

This approach leads to insufficient learning interest and weak practical abilities among students, making it difficult to form effective cross-cultural communication and dissemination behaviors.The Evaluation Index System of International Communication Efficiency is shown in Table 1:

TABLE 1. Evaluation Index System of International Communication Efficiency

Dimension	First-level Indicators	Second-level Indicators	Weight
Cognitive Dimension	Cultural knowledge & comparison ability	Mastery, logic, clarity, accuracy	0.25
Empathetic Dimension	Cultural respect & tolerance	Empathy, openness, inclusiveness	0.25
Competence Dimension	Communication & critical thinking	Expression, adaptation, conflict-solving	0.25
Communication Dimension	Willingness & effect	Motivation, strategy, acceptance, impact	0.25

C. INDIVIDUAL ADAPTATION LEVEL: LACK OF UNIFIED TEACHING AND INDIVIDUALIZED TEACHING

The composition of students in cross-cultural classes in universities is complex and there are significant individual differences

Language proficiency differences: from zero foundation to fluent expression, with a huge span;

Cultural background differences: Local students, international students, and exchange students coexist, with different cultural cognitive starting points;

Cognitive style differences: Some excel in visual learning, some excel in auditory learning, and some excel in practical learning;

Emotional attitude differences: Different levels of openness, tolerance, and learning motivation towards different cultures.

However, traditional teaching adopts the model of "unified progress, unified content, and unified evaluation", which cannot adapt to individual differences, resulting in "high achieving students not getting enough to eat and low achieving students not keeping up", and polarization of learning outcomes.

D. EFFECT EVALUATION LEVEL: SUBJECTIVE QUALITATIVE EVALUATION IS THE MAIN FOCUS, WITH INSUFFICIENT QUANTIFICATION

Traditional evaluation mainly relies on exams, homework, classroom performance, and teacher comments, which have three major shortcomings:

Single evaluation dimension: focusing on cultural knowledge memory, neglecting core abilities such as empathy, conflict response, and communication willingness;

Strong subjectivity: Teacher comments rely on personal experience and are difficult to objectively reflect students' true state;

Process oriented deficiency: focusing on summative evaluation, lacking tracking and intervention of the learning process.

This evaluation system cannot provide data support for precise teaching improvement, nor can it scientifically measure the role of teaching in enhancing international communication effectiveness.

E. INTERNATIONAL COMMUNICATION LEVEL: DISCONNECTED BETWEEN TEACHING AND COMMUNICATION, WEAK CONVERSION ABILITY

There is a serious disconnect between current teaching and international communication practices, with three major problems:

Lack of goal orientation: Failure to make international communication skills a core teaching objective, resulting in a disconnect between teaching content and communication needs;

Insufficient scenario training: Lack of practical training in real-life public opinion scenarios, cross-cultural dialogue, conflict response, etc;

Lack of conversion mechanism: A conversion path of "cultural knowledge cross-cultural competence dissemination behavior" has not been established, making it difficult for students to transform knowledge into effective dissemination abilities.

This disconnect leads to students having knowledge but no ability, and having ability but no willingness, which cannot meet the needs of the national cultural dissemination strategy. Multimodal Data Types and Application Purposes are shown in Table 2:

TABLE 2. Multimodal Data Types and Application Purposes

Modality	Data Source	Key Features	Application Purpose
Text	Answers, dialogues, essays	Semantic, attitude, logic	Cultural attitude, expression analysis
Audio	Speech, tone, speed	Emotion, fluency, confidence	Emotional state, communication ability
Visual	Face, gesture, gaze	Attention, expression, engagement	Engagement, emotional state
Interaction	Clicks, response time	Load, progress, effort	Cognitive load, learning progress

F. CORE REQUIREMENTS FOR AI EMPOWERMENT

In response to the above difficulties, the core needs of AI empowering cross-cultural education can be summarized into five categories:

1. Multimodal perception needs: comprehensively perceive students' learning status, emotional attitudes, and behavioral tendencies, and provide data support for precise intervention;
2. Adaptive teaching needs: dynamically adjust teaching content, difficulty, and pace based on individual student characteristics to achieve personalized teaching;
3. Immersive simulation needs: Build real cross-cultural communication and dissemination scenarios to enhance students' practical abilities;
4. Quantitative evaluation requirements: To achieve quantifiable and traceable evaluation of cross-cultural competence and international communication effectiveness;
5. Knowledge organization requirements: Build a structured cultural comparative knowledge system to enhance the depth and systematicity of teaching content.

IV. OVERALL DESIGN OF MULTIMODAL DATA-DRIVEN AI CROSS-CULTURAL TEACHING SYSTEM

A. SYSTEM DESIGN OBJECTIVES

The core goal of this article's system design is to enhance cross-cultural competence and improve international communication effectiveness, including:

1. Enhance students' cultural cognition and cultural comparison ability, and establish a complete cultural cognition framework;
2. Enhance students' cultural empathy and emotional attitudes, and cultivate an open and inclusive cultural mindset;
3. Enhance students' cross-cultural communication and conflict response abilities, and strengthen their practical skills;
4. Strengthen students' international communication willingness and communication strategies, and enhance communication efficiency;
5. Realize quantifiable evaluation of the entire teaching process and provide data support for teaching optimization.

The comparison of Teaching Effects Between Experimental Group and Control Group is shown in Table 3:

TABLE 3. Comparison of Teaching Effects Between Experimental Group and Control Group

Indicators	Experimental Group (Pre)	Experimental Group (Post)	Control Group (Pre)
Cognitive Score	70.7	89.6	71.2
Empathy Score	67.8	88.2	68.3
Competence Score	68.6	90.1	69.1
Communication Efficiency	68.2	87.4	68.7
Satisfaction	60.0%	92.7%	58.1%

B. OVERALL SYSTEM ARCHITECTURE

This article constructs a five layer integrated AI cross-cultural teaching system, with each layer working together to form a complete closed loop:

1. Perception layer: a multimodal data acquisition module responsible for collecting data such as text, speech, facial expressions, posture, and interaction;

2. Data layer: data cleaning, fusion, storage, and annotation modules, responsible for data preprocessing and management;

3. Model layer: Core algorithm modules, including cultural knowledge graph, sentiment computing, adaptive learning, intent understanding, etc;

4. Teaching layer: Core teaching function modules, including cultural comparison teaching, situational simulation, virtual dialogue, intelligent feedback, etc;

5. Application layer: User oriented interactive interface, including classroom teaching, self-directed learning, international communication training, effectiveness evaluation, etc.

C. CORE FUNCTIONAL MODULES

D. CULTURAL COMPARISON KNOWLEDGE GRAPH MODULE

Function: Structurally model Chinese and Western values, ways of thinking, communication customs, and discourse systems, and construct a knowledge network of "concept relationship instance";

Core competencies: Visual retrieval, cross-cultural comparison queries, knowledge association recommendations, dynamic updates;

Function: To provide systematic cultural content for teaching and help students establish a complete cultural cognitive framework.

E. MULTIMODAL EMOTION AND BEHAVIOR PERCEPTION MODULE

Function: Real-time collection of facial expressions, voice emotions, text emotions, posture, and interaction data to generate learning state portraits;

Core competencies: emotion recognition, cognitive load assessment, engagement analysis, cultural attitude recognition;

Function: To provide data support for adaptive teaching and precise intervention, and achieve panoramic perception of students' status.

The comparison of Teaching Effects Between Experimental Group and Control Group is shown in Table 4:

TABLE 4. Comparison of Teaching Effects Between Experimental Group and Control Group

Module	Core Function	Technical Approach	Improvement Effect
Knowledge Graph	Structured cultural comparison	Knowledge graph, visualization	Knowledge mastery +22.4%
Multimodal Sensing	Learning state recognition	Multimodal fusion, sentiment analysis	Intervention accuracy +34.2%
Adaptive Learning	Personalized path	Recommendation algorithm, learner profile	Learning efficiency +28.5%
Simulation Training	Cross-cultural practice	Virtual human, scenario simulation	Communication ability +30.6%
Efficiency Evaluation	Quantifiable assessment	Multimodal scoring, index calculation	Evaluation objectivity +41.3%

F. ADAPTIVE LEARNING PATH MODULE

Function: Based on students' abilities, emotions, and progress, dynamically recommend learning content, difficulty, cases, and exercises;

Core competencies: learner portrait construction, learning diagnosis, personalized resource recommendation, progress adjustment;

Function: To achieve personalized teaching, reduce individual differences, and improve overall learning outcomes.

Based on cognitive load theory and cross-cultural empathy cultivation paths, a complete and interpretable emotion-teaching strategy mapping library is constructed. When students show confusion or perplexity, the system pushes cultural comparison diagrams, case breakdowns, and step-by-step explanatory materials. When students show fatigue or low attention, the system pushes immersive situational simulation and interactive dialogue tasks. When students show cultural resistance or bias, the system pushes neutral factual materials, multi-perspective cases, and empathy-oriented guidance. When students show high engagement and focus, the system pushes advanced thinking questions and cross-cultural conflict discussion tasks. The entire intervention mechanism is transparent, evidence-based, and highly consistent with the goals of cross-cultural education.

G. CROSS CULTURAL SCENARIO SIMULATION AND DIALOGUE MODULE

Function: Build virtual cross-cultural scenes for students to engage in practical training such as dialogue, negotiation, conflict response, and cultural interpretation;

Core competencies: virtual digital human interaction, scene generation, dialogue feedback, conflict simula tion;

Function: To enhance students' cross-cultural practical abilities and international communication practical skills.

H. INTERNATIONAL COMMUNICATION EFFICIENCY EVALUATION MODULE

Function: Conduct comprehensive scoring from four dimensions: cognition, empathy, ability, and communi cation, generate reports and improvement suggestions;

Core competencies: multimodal data fusion evaluation, efficiency index calculation, personalized report generation;

Function: To achieve quantifiable evaluation of teaching effectiveness and provide data support for teaching optimization and student growth.

V. RESEARCH CONCLUSION AND FUTURE PROSPECTS

A. RESEARCH CONCLUSION

This article draws the following conclusions through theoretical construction, system design, and empirical verification:

1. Currently, cross-cultural education in universities faces five major challenges in terms of content, methods, adaptation, evaluation, and dissemination, and urgently needs to be empowered by AI technology;

2. AI technology reconstructs cross-cultural education from four levels: content layer, experience layer, teaching layer, and evaluation layer, which can effectively solve the pain points of traditional teaching;

3. The AI multimodal cross-cultural teaching system constructed in this article achieves a closed-loop process of "precise perception-adaptive teaching-immersive simulation-quantitative evaluation," significantly improving students' international communication efficiency regarding high-performance fiber technologies and smart weaving craftsmanship. This systematic approach ensures that students can accurately articulate the technical intricacies of functional engineering and advanced material science within a globalized digital environment;

4. Empirical results show that the system can improve the comprehensive score of students' international

communication effectiveness by 28.3%, increase teaching satisfaction by 32.7%, and the effect is significant;

5. A replicable and promotable paradigm of "AI empowerment multimodal perception cultural comparison international communication effectiveness" has been formed, providing a practical path for cross-cultural education reform in universities and the implementation of national cultural communication strategies. The AI-driven multimodal cross-cultural teaching system significantly improves learners' cross-cultural understanding ability, empathy ability, and communication willingness in virtual scenarios, which lays a solid ability foundation and behavioral preparation for the improvement of real international communication effectiveness in the real world.

B. INSUFFICIENT RESEARCH

There are three shortcomings in this study:

1. Limited sample coverage: Only one university student is selected, and the sample type can be further expanded;

2. Insufficient long-term effect tracking: Only a 16-week experiment was conducted, and the tracking of long-term learning effects and dissemination behavior can still be deepened;

3. Large model interaction needs to be optimized: There is still room for improvement in the naturalness of virtual human dialogue, and further integration of large model technology is needed.

C. FUTURE PROSPECTS

Future research will deepen from four aspects:

1. Model structure optimization: Integrating lightweight Transformers with large models to further enhance multimodal perception and dialogue capabilities;

2. Long term effect tracking: Conduct a 12-year tracking study to evaluate the impact of the system on students' long-term cross-cultural competence and communication behavior;

3. Integrated diagnosis expansion: Based on detection, add functions such as fault recognition and cultural bias diagnosis to achieve the integration of "teaching diagnosis intervention";

4. Global Learner Interconnection: Building a global cross-cultural learning community facilitates real-time interaction and cultural dialogue between Chinese and foreign students, specifically focusing on the technical heritage of smart weaving and high-performance fiber artistry. This collaborative environment enhances practical international communication skills by allowing students to exchange expertise on the innovative engineering of functional and advanced material science within a digitized global landscape.

AUTHOR CONTRIBUTIONS

Chunhui Wang designed, collected and analyzed the data, and drafted the manuscript. Chunhui Wang conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Chunhui Wang participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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