

Research on Personalized Teaching Models for English Learners Based on Big Data Analysis

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ABSTRACT

This study focuses on developing a personalized teaching model for English learners, supported by big data technology. Addressing the limitations of traditional teaching methods in adapting to individual differences, the study integrates situational learning theory and educational equity theory to design a core framework comprising four dimensions. A personalized diagnostic system based on learner profiles enables precise assessment of abilities; a flexible resource supply system provides multimodal learning materials on demand; a real-time intervention system dynamically adjusts teaching strategies through learning situation alerts; and an evolutionary assessment system continuously optimizes model parameters through machine learning. Through a triple operational mechanism of initial adaptation, dynamic adjustment, and ecological evolution, the system achieves intelligent iteration of teaching pathways.

KEYWORDS

English learning; Personalization; Teaching model

1 Introduction

The digital transformation of education is reshaping the underlying logic of language learning. The deep integration of intelligent technology and massive data has driven the irreversible development of personalized learning in the global language education field. English teaching is facing a structural conflict between traditional teaching methods and the diverse needs of learners in the context of globalization. A standardized curriculum framework struggles to address the significant differences among individuals in terms of cognitive preferences, language proficiency, and cultural understanding. Situated cognition theory elucidates the symbiotic relationship between knowledge formation and social practice, emphasizing that language skill improvement must be grounded in authentic, culturally relevant contexts. Educational equity theory, based on the principle of equal opportunity, explains the decisive impact of customized resource allocation on achieving substantive fairness. These two theories collectively reveal the core objective of English teaching reform: to establish a new teaching framework that ensures equal educational opportunities while also unlocking individual potential. Although existing technologies can track learning activities in all dimensions, there are still significant bottlenecks in data value mining. Insufficient integration of diverse information leads to analysis remaining at the level of explicit features. Cognitive differences between algorithmic mechanisms and language acquisition principles cause intervention measures to deviate. A rigid resource system that cannot support continuous evolution creates a dynamic matching dilemma. These shortcomings mean that current technical solutions mostly remain at the level of auxiliary tools and have not led to systematic innovation in teaching models. Existing research generally suffers from issues such as the disconnect between technological application and educational principles, mismatches between resource allocation and cognitive development, and the separation of effectiveness evaluation from growth trajectories, highlighting the severe lack of educational theory integration in the development of intelligent education systems. How to bridge the gap between the tool-oriented nature of technology and the intrinsic nature of education, and achieve a thorough reconstruction of teaching paradigms through theoretical model innovation, has become a core challenge that must be overcome to advance English education reform.

2 Theoretical foundations

2.1 Situated learning theory

Situated learning theory provides an essential explanatory framework for language acquisition mechanisms. The development of language proficiency is fundamentally a process by which learners gradually construct their identity within a social practice community. English instruction must focus on the intrinsic connection between language forms and communicative functions. Discrete knowledge point training lacking authentic pragmatic contexts tends to result in inert knowledge accumulation. There is an inevitable connection between individual cognitive development and group interaction. The meaning negotiation mechanisms in cross-cultural dialogue are more effective than isolated exercises in promoting the internalization of pragmatic abilities. The degree of alignment between learning trajectories and cultural

contexts constitutes a key variable. Pure skill training detached from cultural identity will lead to a decline in learning motivation. Current intelligent teaching systems generally simplify contexts into audiovisual simulations, failing to recreate the complex participatory structure of social practice. This necessitates a redesign of the real-time intervention system in this model. By integrating social practice platforms such as virtual language communities and real-world cross-cultural projects, data-driven personalized teaching can return to the fundamental attribute of language as a tool for social communication ^[1].

2.2 Theory of educational equity

The theory of educational equity forms the ethical foundation for model design. Distinct from the principle of formal equality of opportunity, Amartya Sen's concept of capability approach focuses on the pathways to realizing learners' substantive developmental freedom, driving English language instruction from standardized resource allocation toward the precise cultivation of individual learners' feasible capabilities. This theory imposes significant constraints on personalized design. At the operational level, it is necessary to identify implicit differences in learners' abilities, such as academic language acquisition barriers caused by a lack of cultural capital or differences in information processing patterns among students with special needs. A flexible resource supply system should establish multimodal adaptive support mechanisms. If algorithmic diagnosis overly relies on test data, it may transform differences in educational resource allocation into ability labels ^[2]. The evolutionary assessment system of this model therefore introduces a counterfactual fairness assessment framework, continuously adjusting environmental bias parameters by comparing the developmental trajectories of learners with similar starting points. This cognitive paradigm, which views fairness as a dynamic regulatory process, drives a substantive evolution of educational fairness concepts from the resource allocation dimension to the developmental process dimension.

3 Core architecture design of personalized teaching models for English learners

3.1 Personalized diagnostic system

The personalized diagnostic system analyzes learners' abilities through multi-source behavioral data. A distributed sensor network continuously captures cognitive traces in natural contexts, including speech rhythm variation patterns, writing vocabulary density distribution, and pragmatic correction behaviors in real-time conversations. The neurocognitive mapping model establishes a quantitative association between the intensity of prefrontal cortex activation and communicative strategies, concretizing working memory capacity as the real-time parsing efficiency of complex syntax. This mechanism identifies implicit obstacles that traditional tests cannot capture. For example, when oral output exhibits fluctuations in grammatical accuracy while maintaining stable fluency, the system automatically flags potential language rigidity. The dynamic Bayesian network serves as the diagnostic engine, with its conditional probability nodes continuously integrating contextual variables to provide accurate diagnoses. A typical application is in detecting register confusion in business English writing, immediately activating the cross-cultural schema analysis module. This paradigm facilitates a transition from discrete indicators to a neural behavioral continuum, evolving diagnostic results from static snapshots to dynamic trajectory visualizations. The system also incorporates a metacognitive monitoring mechanism. When learners repeatedly ignore grammatical feedback, it automatically generates a cognitive style analysis report ^[3].

3.2 Elastic resource supply system

The construction of an elastic resource supply system can be based on the dynamic adaptation framework of cognitive load theory. A multi-dimensional semantic space model deconstructs text into conceptual abstraction, cultural reference density, and mental processing requirements. When identifying metaphor comprehension barriers among academic English learners, the resource engine initiates a cross-domain mapping protocol to extract alternative texts with similar conceptual structures but reduced cultural load, linking them to three-dimensional anatomical models as concrete scaffolding. Material reorganization follows the Zone of Proximal Development optimization algorithm, which controls cognitive tension in input items by monitoring the cognitive friction coefficient during schema reconstruction. The special needs module adopts neuro-diversity design principles. For individuals with reading disabilities, the reinforcement system dynamically adjusts text visual parameters, including fine-tuning letter spacing and enhancing character outlines, combined with precise timing of auditory feedback. The core of the multi-channel adaptation mechanism lies in establishing a match between knowledge representation modalities and individual neural processing pathways ^[4].

3.3 Real-time intervention system

The objective of the real-time intervention system is to create an environment that promotes language skill development. It primarily focuses on analyzing language behaviors in daily social activities. When encountering topics that cannot be successfully communicated, the system generates an interactive platform that mimics real-world social and cultural environments, using conversational scenarios to guide students in recognizing the necessity of cross-cultural understanding. The evaluation of intervention effectiveness should also consider factors such as students' workload and participation levels. The system adjusts in real time based on the actual situations and reactions generated by students during negotiation processes to better meet their needs. When students feel uncertain about applying complex communication skills, the system can make specific guiding adjustments, enabling students to tackle challenging tasks without feeling limited by their capabilities. It focuses on the social nature of language learning and students' active development in communicative contexts. It uses appropriate guidance methods to ensure that all students can fully participate in language practice.

3.4 Evolutionary Evaluation System

The evolutionary evaluation system promotes the evolution of education and teaching, as well as the dynamic language ecosystem. After adding cultural intelligence evaluation indicators, various cultural and original scenarios were established, and the system tested the prediction accuracy of the model based on cultural comprehension deviation parameters to confirm the accuracy of this indicator in predicting the effectiveness of cross-cultural dialogue. Bidirectional feedback loops are the two primary drivers of this system's evolution. Small feedback loops continuously utilize data streams generated by educational teaching to adjust parameters of neural cognitive models, such as the correlation coefficients between grammatical complexity and working memory capacity. Large feedback loops periodically update semantic space expression models and monitor the historical divergence of disciplinary dialogue styles. This dual-evolution strategy successfully avoids the common issue of concept drift in self-adaptive systems. The system generates a sensitivity analysis report on model parameters based on the degree of discrepancy between predicted trajectories and actual developments in a simulated environment, and continuously improves the system accordingly.

4 Design of the operating mechanism

4.1 Initial adaptation mechanism

The initial adaptation mechanism prepares personalized teaching tailored to an individual's initial learning ability. At this stage, monotonous static evaluation tools are no longer used. Instead, dynamic information is continuously obtained through natural English tasks. The initial adaptation mechanism not only focuses on the content of language output—such as whether grammar rules and vocabulary are used appropriately—but also delves into the more profound influences of how students approach problem-solving, including how they select relevant information from reading materials, how they conceptualize and write articles. The level of emotional engagement and confidence demonstrated in communication during tasks. By understanding these behavioral characteristics, an accurate "student profile" is created, clearly identifying each student's strengths, areas needing improvement, and potential barriers to learning. For example, assessing students' speech characteristics in group discussions can evaluate their oral expression fluency while also understanding their reasoning ability, problem-solving skills, and preferences for utilizing different cultural reference frameworks. By conducting diagnostic assessments in real language practice activities, the effectiveness and specificity of educational interventions can be ensured, avoiding the overly generalized or labeling tendencies of traditional grouping methods^[5].

4.2 Dynamic adjustment mechanism

The dynamic adjustment mechanism can quickly identify and respond to students' changing learning and development needs, thereby making teaching methods more flexible and tailored. This process consists of a continuous cycle of ongoing observation, immediate interpretation, specific feedback, and dynamic correction. The system continuously monitors and evaluates whether learners' learning activities (such as exercises, verbal communication, and assistance requests) are ongoing and when they occur. Once the system detects that a learner is in difficulty or has made significant progress, it immediately conducts an analysis. This analysis does not merely focus on errors; it also examines the broader context. Still, it considers the student's overall thinking patterns, the environmental conditions during task completion, and their prior learning history, thereby providing a comprehensive assessment. The results of these analyses

guide the immediate adjustment of subsequent teaching plans. Understanding the student's "zone of proximal development" means providing timely support without overly focusing on the child's independent exploration area, thereby avoiding prolonged feelings of frustration due to lack of progress.

4.3 Ecological evolution mechanism

The ecological evolution mechanism endows teaching methods with flexibility and long-term adaptability, enabling them to accommodate increasingly diverse learning needs and social contextual demands. This process manifests in two primary aspects. First, each individual within the model possesses autonomous learning capabilities. The system tracks the personalized educational pathways of each learner and analyzes the specific impacts of different intervention methods on various learner types in particular scenarios. Through standardized data collection and analysis, the system can adjust diagnostic models, resource allocation rules, and intervention methods tailored to specific groups, thereby enhancing the precision of future instruction. Second, the model also demonstrates adaptability to external environmental changes at the macro level. The system remains vigilant regarding new trends in language education, such as the rising demand for digital literacy and changes in English language usage standards across specific industries. By regularly comparing model parameters, evaluation criteria, and resource library materials against current social contexts, the system automatically identifies potential issues and lagging phenomena.

5 Conclusion

This study established a big data-driven, personalized English teaching model that integrates situational learning and educational equity theory, overcoming the limitations of traditional teaching through a four-dimensional framework. The personalized diagnostic system accurately assesses abilities, the flexible resource supply system dynamically configures multimodal materials, the real-time intervention system adjusts strategies based on student performance, and the evolutionary assessment system continuously optimizes parameters. This model relies on three mechanisms—initial adaptation, dynamic adjustment, and ecological evolution—to achieve intelligent evolution of teaching paths, transforming personalized teaching into a continuous process of co-evolution between learners and the environment. It promotes the substantial development of language abilities while ensuring educational equity, providing a practical framework for the digital transformation of education.

About the Author

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