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Construction and Practice of Lightweight AI Teaching Framework with Ethics Priority: A Study on Differential English Teaching in Junior High Schools from the Dimension of Cultural Competence

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Abstract: This study constructs an ethics-first lightweight artificial intelligence teaching framework aiming at the practical problems existing in junior middle school English differential teaching, such as rigid stratification mechanism, lack of cultural literacy cultivation and ethical disputes of technology application. The framework realizes non-inductive data collection based on smartphone sensors, uses federated learning technology to build a dynamic grouping model, and incorporates cultural competence as the core dimension into the hierarchical system. A one-semester teaching experiment among 326 students in the eastern, central and western regions shows that the grouping accuracy rate of this framework reaches 89%, students' cultural understanding ability is improved by 44%, the grammatical error rate is reduced by 31%, and the parent data withdrawal request rate is reduced to 0.9%. Research confirms that this framework provides a scalable practical scheme for promoting educational equity through ethical compliance design and lightweight technology path.

Keywords: Differential teaching; Federated Learning; Educational equity; Cultural competence; Ethical artificial intelligence

1. The question put forward: the realistic dilemma and reform demands of junior middle school English differential teaching

With the in-depth implementation of the “Compulsory Education English Curriculum Standards (2022 Edition)”, core literacy-oriented teaching transformation has become a clear direction of junior high school English education. The new curriculum standard particularly emphasizes the improvement of students' cross-cultural communication ability through the cultivation of cultural awareness, and realizes the unity of instrumental and

humanistic English subjects[1]. However, as a front-line teacher, the author observed in the actual teaching process that there is a significant gap between ideal differential teaching practice and classroom reality, which is mainly reflected in the structural contradictions in the following three dimensions:

1.1. Rigidity of stratification mechanism and insufficient adaptability of teaching dynamics

At present, there is a widespread phenomenon of "pseudo-stratification" in junior middle school English differential teaching, and its core problem lies in the single stratification standard and the static stratification. Most schools rely on summative evaluation results such as mid-term and final exams for one-time grouping, and the grouping results often last for the whole semester without adjustment. This solidification and stratification mode ignores the dynamic development characteristics of students' abilities, resulting in a serious disconnect between the grouping results and the actual learning situation: high-level students' thinking is limited due to lack of sufficient challenges, and low-level students' confidence is frustrated due to the label effect, which ultimately makes teaching students in accordance with their aptitude stay at the conceptual level[2]. This mechanical hierarchical mechanism not only is difficult to adapt to the nonlinear characteristics of students' cognitive development, but also strengthens the "Matthew effect" in the educational process to some extent, which runs counter to the original intention of promoting students' all-round development.

1.2. The lack of cultural literacy cultivation is out of touch with the requirements of curriculum standards

In the concrete implementation process of differential teaching, the cultivation of cultural literacy is often marginalized. Most of the existing hierarchical teaching practices focus on the training of language knowledge and skills, and differential teaching is simplified to different requirements of grammatical structure and vocabulary mastery, while the cultivation of cultural awareness emphasized by the new curriculum standard lacks a systematic integration path. Through teaching observation, the author finds that nearly 90% of differential teaching schemes do not design in-depth cultural comparison and reflection tasks, and cultural teaching stays at the cognitive level of superficial symbols such as festivals and diets. This tendency of "emphasizing language over culture" makes English teaching lose its essential attribute as a cross-cultural communication tool, and it is difficult for students to form real cultural understanding and global competence, which is significantly different from the literacy-oriented teaching goal put forward by the new curriculum standard.

1.3. The ethical dilemma of technology application and the conflict of educational humanistic values

With the rapid penetration of artificial intelligence technology in the field of education, intelligent teaching equipment provides new possibilities for differentiated teaching. However, the current technology application faces significant ethical challenges and practical obstacles. On the one hand, although perception technologies such as face recognition and eye tracking can provide detailed learning behavior data, their high cost is beyond the affordability of

most schools, especially those in areas with weak resources; On the other hand, these technologies involve the collection of students' biometric characteristics, which has caused parents' deep concerns about privacy security. In the actual teaching, the author observed that about one-third of parents expressed clear opposition to classroom monitoring technology. This resistance not only affected the quality of home-school cooperation, but also reflected the deep contradiction between technical rationality and educational humanistic value. How to make full use of technological advantages and ensure the ethical legitimacy of the educational process has become a key problem that the differential teaching reform must face.

The above three difficulties are intertwined, which together constitute the deep obstacles to the reform of English differential teaching in junior middle schools. Static stratification leads to the lack of accuracy in teaching, the lack of culture leads to the deviation of teaching objectives, and ethical disputes hinder the teaching innovation empowered by technology[3]. The existence of these problems urgently requires us to explore a new teaching path that can not only respect students' individual differences, but also deeply integrate the cultivation of cultural literacy, and strike a balance between technology and ethics. Based on this realistic demand, this study tries to construct a lightweight differential teaching framework with ethics priority and technology empowerment, aiming to provide practical practical solutions for front-line teachers.

2. Practical framework: Construction of a lightweight teaching model with ethics first

In order to solve the structural dilemma of differential English teaching in junior high schools, this study constructs a lightweight teaching framework with ethics priority, the core of which lies in the deep integration of technological empowerment and teaching practice through the collaborative design of dynamic grouping, cultural integration and ethical guarantee. The framework is based on popular mobile terminal equipment, deeply integrates federated learning algorithms and multi-dimensional behavior analysis technology, and realizes the coordinated development of dynamic grouping, cultural integration and ethical guarantee through three-tier architecture design, providing a set of innovative and operable practical solutions for front-line teaching scenarios.

2.1. Design and implementation of minimalist data collection scheme

In this study, a lightweight data acquisition scheme based on smart phone sensors is innovatively adopted, and the self-developed embedded monitoring program is used to realize the non-perceptual learning situation acquisition in the teaching process. This solution relies on a variety of sensors built into mobile phones to continuously capture the in-depth interactive behaviors between students and digital learning content, including but not limited to key behavioral indicators such as the screen stay time of knowledge point pages, the thermal distribution of interface sliding trajectories, and the time series of task responses. In practical teaching applications, the system shows excellent adaptability: when it is detected that the student's stay time on a specific grammar knowledge point page significantly exceeds the average value of the peer group, it will automatically identify it as a potential cognitive impairment point and generate a multi-dimensional learning situation early warning report. This non-invasive data collection method not only completely maintains the natural ecology of the teaching process, but also provides rich and reliable empirical basis for subsequent dynamic grouping and personalized intervention, effectively solving the problem that the diagnosis of secondary situation in traditional teaching depends on subjective experience.

2.2. Theoretical basis and implementation path of dynamic layering mechanism

The dynamic hierarchical mechanism constructed in this study is guided by cognitive constructivism theory, and adopts a dynamic evaluation model with weekly iteration cycle, which completely breaks through the inherent limitations of traditional static grouping. This mechanism establishes a comprehensive evaluation system of two dimensions of cognitive ability and cultural understanding: in the cognitive dimension, students are divided into three teaching levels: basis, improvement and expansion according to the accuracy and knowledge mastery of unit tests; In the dimension of cultural understanding, by designing systematic cross-cultural cognitive tasks, students' core literacy indicators such as the accuracy of cultural symbol recognition and the depth of cultural metaphor interpretation are quantitatively evaluated[4]. This layered technology relies on advanced federated learning algorithms, and on the premise of strictly protecting the privacy of individual data, it generates a scientific grouping scheme through the secure aggregation of encryption parameters. This mechanism not only ensures the timeliness and accuracy of teaching grouping, but more importantly, it realizes the concept change from "label stratification" to "developmental stratification", so that grouping can really serve students' ability development.

2.3. Systematic construction of ethical compliance guarantee system

The hierarchical informed consent mechanism pioneered in this study constructs a complete ethical compliance guarantee system, and deeply embeds ethical considerations into all aspects of technology application. The system adopts a step-by-step authorization design: the basic teaching level only needs to authorize the collection of basic behavior data, and parents can complete quick authorization through convenient electronic methods; For advanced collection of sensitive data such as voice and images, parents must sign an agreement independently after fully understanding the purpose of data use and protection measures through special briefings[5]. At the level of data security, all collected information is processed by strict differential privacy technology, and the non-re-identifiability of individual information is ensured by adding precisely calculated noise data. This systematic design not only fully respects parents' data sovereignty and informed choice, but also builds a solid institutional guarantee for the compliant application of educational technology, and lays a trust foundation for the sustainable advancement of innovative teaching models.

3. Practice process and effect analysis

In order to comprehensively verify the effectiveness and applicability of the constructed teaching framework, this study selected three typical representative regional samples of eastern cities, central counties and towns and western villages to carry out one-semester teaching practice, and systematically evaluated the teaching process and effect through a multi-dimensional index system.

3.1. Implementation path and strategy of hierarchical teaching

In the process of teaching implementation, this study designs a gradient teaching scheme that is highly adapted to the dynamic layering mechanism, forming a complete set of

differentiated teaching implementation paths[6]. At the basic level, teaching focuses on the embodied cognition of cultural symbols, creates immersive learning scenes through AR augmented reality technology, and guides students to establish a preliminary relationship between cultural symbols and meanings through virtual and real interaction; At the advanced level, the focus of teaching turns to the systematic cultivation of symbol decoding ability, and students are guided to deeply analyze the metaphorical differences and value logic behind cultural phenomena through carefully designed task of comparing Chinese and Western cultures; At the level of expansion, it focuses on developing students' critical thinking and cross-cultural communication skills, and cultivates students' multiple perspectives and deep thinking skills by organizing challenging seminars and debates on cultural issues. Teaching tasks at all levels form a complete teaching closed loop through federated learning technology, realizing a continuous optimization cycle from ability diagnosis, strategy matching to effect evaluation, ensuring the accuracy and effectiveness of teaching intervention.

3.2. Empirical Analysis and Discussion of Teaching Effect

After a semester of teaching practice, the empirical data collected fully proves the multi-dimensional effectiveness of the framework. In terms of grouping accuracy, the accuracy rate of the dynamic hierarchical model reaches 89%, which is 32% higher than that of the traditional static grouping, showing the keen ability to capture the dynamic changes of students' abilities. At the level of students' ability development, the grammar mastery level of students in the experimental group has been significantly improved, and the error rate shows a systematic downward trend. Among them, rural school students have made particularly significant progress in complex grammar items such as attributive clauses. What's more, students' cultural understanding ability has shown a comprehensive improvement, and the post-test score of cross-cultural sensitivity scale has increased by 44% compared with the pre-test. This data strongly confirms the positive impact of cultural dimension intervention on core literacy cultivation. In addition, qualitative analysis (such as the analysis of students' homework texts and classroom discourse) further shows that the students in the experimental group show richer expression content and more critical thinking level in the discussion of cultural topics, which shows that the implementation of the framework not only improves students' language ability, but also promotes the all-round development of their comprehensive literacy.

3.3. Systematic verification and enlightenment of regional adaptability

Cross-regional systematic comparative analysis further confirms that this framework has good resource adaptability and popularization value. At the level of equipment investment, the lightweight design based on smart phones controls the per student cost of rural schools within 35% of that of urban schools, significantly lowering the threshold of technology application. At the level of teaching effect, despite the difference in resources, the core teaching indicators of rural schools remain at a high level, and the completion rate of cultural tasks is stable at 81%, which is significantly higher than the baseline level of traditional teaching. It is particularly noteworthy that the unit cost-benefit ratio of rural schools even shows comparative advantages under the condition of controlling the initial ability variables. This finding provides important enlightenment for educational technology innovation in the resource-constrained environment[7]. To sum up, the empirical results show that this lightweight model has significant resource adaptability, and its “low cost and high flexibility”

characteristics provide a highly feasible technical path for bridging the digital divide in education and promoting basic equity. Its “low cost and high adaptability” characteristics make it a feasible path to promote basic education equity, and provide valuable practical reference for solving the “digital divide” problem in the digital transformation of education.

4. Discussion and Enlightenment: Practical Reflection on Educational Technology Empowering Differential Teaching

Based on the one-semester teaching practice and systematic evaluation, the ethics-first lightweight teaching framework constructed in this study shows significant application value and practical feasibility in junior middle school English differential teaching. Through in-depth reflection on the whole practice process, we have obtained the following core enlightenment, in order to provide useful reference for the deep integration of educational technology innovation and subject teaching.

4.1. Technology positioning: from disruptive substitution to supportive empowerment

The practical results of this study confirm the reasonable positioning of educational technology in educational reform-technology should be used as an enabler rather than a disruptive force in the teaching process[8]. In teaching practice, smart phones and lightweight applications are not designed to replace teachers' professional judgment and humanistic care, but to extend teachers' teaching perception ability and assist them in making more targeted teaching decisions by providing accurate learning data and scientific analysis tools. This orientation of “people-oriented, technology-oriented” not only gives full play to the advantages of information technology in data processing and pattern recognition, but also ensures the dominant position of teachers in the teaching process, effectively avoiding the possible risk of educational alienation caused by “technology supremacy”. In the future, the development of educational technology should pay more attention to the fit with the essence of education, and strive to build a new teaching ecology of human-machine collaboration.

4.2. Ethical guidelines: from compliance requirements to trust cornerstones

Through the design of mechanisms such as hierarchical informed consent and differential privacy protection, this study confirms that ethical considerations are not only legal compliance requirements for technology applications, but also the cornerstone of trust in establishing a sustainable educational innovation environment. In the process of teaching practice, parents' high recognition and active cooperation with data collection methods are directly transformed into social capital and psychological capital promoted by teaching reform. This finding suggests that educational technology innovation must give priority to ethical design, and build a trinity of technology, education and social trust through measures such as transparent data use, differentiated authorization selection and strengthened privacy protection[9]. Only when the application of technology wins the widespread trust of students, parents and educators can the digital transformation of education truly take root and achieve sustainable development.

4.3. Cultural integration: from surface contact to deep construction

This study demonstrates the symbiotic relationship between cultural literacy cultivation and language ability development by integrating the cultural competence system into the differential teaching framework. Practical results show that when cultural teaching is upgraded from simple symbolic cognition to deep value understanding and critical reflection, students not only improve their cross-cultural sensitivity, but also enhance the richness of their language expression and thinking depth simultaneously. This fully shows that the cultural dimension should not be the subsidiary content of language teaching, but the core element of reconstructing teaching objectives, processes and evaluation. The future reform of English teaching should further deepen the understanding of the connotation of cultural literacy, and through a carefully designed cultural infiltration learning environment, students should deepen their identity with their own national culture while understanding other cultures, so as to truly realize the comprehensive promotion of the educational value of English subjects.

To sum up, this study provides an operational and practical path to solve the practical dilemma of junior middle school English differential teaching through the lightweight teaching framework of ethics priority[10]. Its core enlightenment lies in: educational technology innovation centered on student development should adhere to the educational position of technology empowerment, build a trust mechanism led by ethics, and deepen the literacy orientation of cultural infiltration. Only in this way can educational technology really serve the improvement of educational quality and make substantial contributions to promoting educational equity and high-quality development. On this basis, future research can further explore precise breakthroughs in technologies such as speech assessment, as well as the development and improvement of critical thinking assessment tools, and continue to promote the development of differential teaching to a deeper level.

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