Research on the Reform Strategy of Primary School Information Technology Teaching Driven by Virtual Digital Human Technology

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[**Abstract**] The rapid development of the virtual digital human industry has brought about the reorganization of teaching space, profoundly changing the education models of all levels and types of schools, and ultimately promoting the reform and innovation of primary school information technology teaching. In response to the current problems of low attention from schools, insufficient professional competence of teachers, poor teaching effectiveness, weak student cooperation awareness, and incomplete evaluation system, based on the study of specific application cases of virtual digital humans in teaching, it is proposed to improve infrastructure construction, and accelerate technological innovation and investment; promote the transformation of teachers' roles, and strengthen professional development training; design diversified teaching content, and carry out interactive teaching; optimize the education evaluation system, and establish strategies such as home-school interactive cooperation mechanism, to optimize information technology classroom teaching, comprehensively enhance students' core competencies, and promote higher levels of education equity and quality through new technologies.

[**Key words**] virtual digital human technology; primary school information technology; teaching reform; teaching application; teaching strategy

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1 Introduction

With the unstoppable penetration of interactive intelligence technology into various industries, digital humans are transitioning from technological innovation to industrial applications, driving the education industry to experience tangible changes in serving teaching scenarios. This indicates that digital education has become a necessary path for China to achieve modernization of education and technological strength in the future. "Modernization of Education in China 2035" regards digital education as an important way to promote educational modernization, emphasizing its important role in improving education quality, promoting education equity, and enhancing teachers' capabilities, curriculum reform, and other aspects. By comprehensively promoting digital education, China aims to achieve a more equitable and high-quality education system by 2035, providing strong support for economic and social development and the enhancement of national competitiveness. In this historical process, virtual digital human technology, as an emerging field of digital education, has gradually discovered its application value and will establish a deep relationship connection with real humans. However, technological innovation and application often come with multiple challenges such as education technology updates, improvement of teachers' digital literacy, overall digital transformation of education, and education equity. In this new era full

of opportunities and challenges, how to respond to these challenges and provide customized full stack virtual digital human production solutions for teachers and students with different needs has become an important mission for the education industry to explore education equity and quality improvement. It has become a shared responsibility of the education sector and various fields of society in the new era.

2 Overview of virtual digital human technology

2.1 The development history of virtual digital humans

Virtual digital human refers to a digital character generated through computer graphics and artificial intelligence technology, with human appearance, behavior, and intelligent characteristics. It not only possesses human emotions and language, but can also express realistic forms through 3D models and animations. It also has the ability to recognize external environments and interact naturally with users. With its continuous expansion in various fields such as education, entertainment, and healthcare, it has gradually become an intermediary for the interaction between humans and the virtual world.

The development of virtual digital humans has gone through four important stages. In the 1980s, due to limitations in computer technology, it was limited to hand-drawn models and animated character design, mainly focusing on the fields of entertainment and education; in the 1990s, the advancement of 3D modeling and animation technology made the forms of virtual digital human expression become increasingly diverse, and further presented its application in the medical and customer service industries in the public eye; entering the 21st century, the rapid development of artificial intelligence has made it possible for virtual digital human technology to shift from rule-based and template-based to data-driven, enabling it to not only perform simple tasks but also engage in intellectual and emotional interactions with users; since 2016, film and television, VR technology, and social services have become key areas for the application of virtual digital humans. Thanks to breakthroughs in deep learning algorithms, virtual idol technology has injected sustainable development momentum into teaching reform, helping the education industry reduce costs and improve efficiency.

2.2 The current application status of virtual digital humans in the field of education

With the rapid development of virtual digital humans in the education industry, their functions and expressive power are constantly improving. China has placed the innovation education of virtual digital humans at the height of the development of the times and the demand for future talents, and has continuously pushed the construction of the talent team to a new level. The virtual teacher developed by Beijing Normal University serves as an important driving force for educational reform, providing personalized learning guidance and continuous support for students. Through interactive feedback, students can obtain learning suggestions, bridge learning gaps, and enhance learning participation. A certain middle school in Zhejiang Province has integrated virtual classroom applications into the entire teaching process of lesson preparation, teaching, homework, examination, management, and evaluation. Teachers customize personalized learning plans for students based on full scenario teaching data, and students achieve "determination" of improving their core competencies in a diverse and integrated virtual digital human space.

From the perspective of foreign education needs, students seek a balance between teachers, personalized teaching, and learning abilities. The first two affect the improvement of teaching efficiency, while the latter determines the quality of students' learning. Each student has the right to choose a space that suits their own ability development, and the choice of many students constitutes the overall pattern of teachers' teaching needs. Knewton Company in the United States provides teachers with virtual learning assistants, which offer analysis of learning situations and recording of teaching feedback data, providing personalized learning paths and choices for students. Students can obtain customized learning resources and strategies based on their own abilities and traits, and complete intelligent classroom interactive experiences. Carnegie Mellon University's virtual laboratory allows

students to simulate experimental operations through interaction with virtual digital humans, promoting their intuitive understanding of experimental principles and operational norms through the integration of theory and experimental teaching.

In terms of applicability in different education stages, virtual digital humans surpass the limitations of real people and exhibit different emotional and action characteristics. In secondary and higher education, virtual digital humans serve as artificial intelligence teaching assistants. By analyzing students' learning participation and goal achievement, they provide more comprehensive professional knowledge guidance and virtual digital human course learning, promoting their transformation from "learning knowledge" to "strong ability" in virtual human live streaming and performance. In primary school, virtual digital humans replicate the image and actions of teachers or play the role of "important others" that students are more interested in, freeing teachers from repetitive labor and providing customized teaching content based on students' learning attitudes, habits, and abilities. This brings new opportunities for personalized education and intelligent tutoring, attracting students to quickly enter the diversified development track. Due to the uneven cognitive development of primary school students, their attention is easily distracted. Using virtual reality technology to construct a scenario-based virtual teaching environment can maximize external stimuli and stimulate their learning potential. The application scope and prospects of virtual digital humans in primary school are broader than in other stages.

2.3 Support of related technologies

The development of virtual digital humans benefits from the support of related technologies such as artificial intelligence, machine learning, and big data. It is a complex based on computer graphics, speech action synthesis, and other technologies, with human appearance and intelligent interaction capabilities, as well as the ability to perform natural language processing and emotional recognition. Artificial intelligence technology enables virtual digital humans to gradually understand and perceive human emotions through in-depth information acquisition to adapt to the needs of the new social situation. Machine learning algorithms help users learn and optimize knowledge graphs by training AI multimodal models, enhancing their ability to meet personalized needs in different scenarios. Big data analysis accurately determines the design, application, and market scenarios of virtual digital humans, determines the optimization direction of developers for products and the functional settings required by students, and enhances the immersion and experience of educational services. The continuous promotion of virtual reality (VR) and augmented reality (AR) technologies has opened up a creative metaverse for the application of virtual digital humans. Students can obtain rich and colorful digital experiences through real-time interaction and information feedback, promoting classroom teaching towards digitalization and globalization.

3 Challenges faced by primary school information technology teaching

3.1 Characteristics of cognitive development among primary school students

From the perspective of cognitive psychology, the cognitive development of primary school students gradually transitions from concrete visual thinking to abstract logical thinking, but is still closely linked to direct and sensory experience. According to Piaget's theory, primary school students exhibit the following significant characteristics in the learning process. Firstly, concrete and vivid things are more likely to stimulate students' curiosity and exploratory desire, which means that virtual digital human technology enters information technology teaching with its unique advantages, and can present concrete examples in a way that is suitable for both movement and stillness, combining audio and visual elements, giving students a full sensory experience, mobilizing their interest in hands-on practice, and promoting them to discover computer principles and explore solutions to problems through perception and operation of the surrounding world. Secondly, emphasizing the cultivation of students' logical thinking ability has a positive impact on the formation and development of their analytical and reasoning thinking. For information technology teaching, the design of logic games and programming activities not only adds strong

interest and operability to the curriculum, but also comprehensively activates students' thinking ability. After students master the principles and methods of programming, they can use Scratch logic components to design works in a controlled environment by creating real virtual laboratories and application scenarios. Based on programming requirements, they can analyze roles, infer program flowcharts, adapt scripts, and combine functional program blocks to better understand operational steps, master programming skills, and effectively activate the potential of logical thinking. Finally, conducting peer-assisted learning and providing opportunities for students at different levels to participate and experience learning can promote effective interaction among marginalized students. Primary school students' learning activities cannot be separated from peer support. Introducing a team collaboration model in information technology teaching and improving students' classroom participation rate will significantly enhance students' learning motivation and effectiveness.

3.2 Core literacy goals of primary school information technology subject

Firstly, in terms of information awareness and literacy, students are cultivated to independently acquire, analyze, manage, and evaluate information, judge the authenticity, applicability, and security of information, and form a scientific and reasonable view of information and responsibility in information society. Secondly, in terms of digital technology application ability, by effectively managing the learning process and resources through the use of digital resources and tools, students can creatively carry out autonomous and collaborative learning, complete learning tasks, and enhance logical thinking and problem-solving abilities. Thirdly, in terms of innovative thinking and practical abilities, students are encouraged to participate in information technology-related project practices, which can cultivate their hands-on skills and teamwork spirit, and stimulate their creative thinking.

3.3 Challenges faced by primary school information technology teaching

The rapid development of the information society in the 21st century, under the requirements of the new curriculum standards for compulsory education, requires the cultivation of students' core subject literacy to rely on information technology teaching methods. This is an important mission entrusted by the times and an irreversible trend in the future development of education. However, current primary school information technology teaching still faces many challenges.

3.3.1 Schools' emphasis is not strong and the investment is not significant

In the context of the information age, with the gradual infiltration of computer network technology into people's daily lives, work, and learning, significant changes have happened to information technology teaching. However, some schools have not fully recognized the importance of information technology learning, resulting in information technology teaching not receiving the attention it deserves.

Firstly, in many schools, information technology teaching faces significant issues of insufficient resources and equipment. This is mainly reflected in: (1) Schools generally have low financial investment in information technology teaching, which limits the procurement and updating of teaching equipment. Even in some schools with basic equipment, there are still problems with the maintenance and management of existing equipment. The outdated and damaged equipment makes it more difficult for students to fully experience the convenience and fun brought by information technology in practical activities. (2) Teachers' training and support in information technology teaching are insufficient. Although some teachers have basic computer skills, their mastery of emerging technologies and teaching tools is not deep enough, and they lack targeted training opportunities, resulting in ineffective use of existing equipment and software in the classroom, thus greatly reducing teaching effectiveness.

Secondly, as a subject that is at the forefront of the times, information technology has complex and rapidly changing content. The core concepts, latest technologies, and applications of information technology require a long period of in-depth exploration and project practice. However, as the subject of information technology is not within the scope of the exam, the focus of school teaching is still mainly on cultural subjects, with relatively less time and

dedicated teachers arranged for information technology courses. This leads to a lack of continuity and stability in students' learning process, affecting their learning progress and sense of achievement, and directly affecting their competitiveness in future learning.

3.3.2 Deficient understanding of the new curriculum standards and inadequate professional competence of teachers

At present, primary school information technology teaching has not achieved the expected teaching effect for a long time, mainly due to the need for teachers to deepen their understanding of the new curriculum standards. The teachers are still using traditional teaching models and concepts, and unable to adjust teaching strategies in a timely manner, resulting in a lack of direction and focus in teaching. The ideal teaching state should be to enable students to apply information technology knowledge and skills to practical life to solve real-world problems and achieve the integration of knowledge. This can not only enhance students' information literacy, but also cultivate their critical thinking and scientific view of information. However, in practice, teachers only teach students basic concepts and professional terminology of information technology in a simple and rough way, neglecting the cultivation of students' practical application abilities, resulting in a disconnect between the knowledge taught and students' actual needs, which affects students' interest and initiative in learning.

With the rapid development of information technology, the demand for teachers in information technology teaching from the education field is increasing. In the context of promoting educational modernization and achieving high-quality education development, the role of teachers is becoming increasingly important. However, there are obvious deficiencies in the professional competence of some teachers, specifically reflected in the update of professional knowledge and the improvement of teaching abilities. Information technology is a rapidly developing and constantly changing field, with new technologies, tools, and applications constantly emerging. If teachers fail to keep up with these changes in a timely manner and lack understanding of the latest technological trends and knowledge, the content they teach in the classroom will be slightly lagging behind, and unable to effectively meet students' learning needs, leading to a decrease in students' interest in the subject and affecting students' deep understanding of information technology. It can be seen that the professional competence of teachers is directly related to students' learning experience and future development. If teachers cannot master cutting-edge information technology and teaching methods, and lack self-improvement motivation and ways, their professional growth will enter a plateau area of development, and it will be difficult to seek breakthroughs.

3.3.3 Students have obvious personality differences and the teaching method is single

In information technology teaching, there is a significant difference in students' basic level, which is particularly evident in the classroom teaching process. Specifically, some students have rich knowledge and operational experience in computer and related technologies, and are able to propose unique insights and questions, easily understanding and applying course content. However, some students have obvious deficiencies in basic skills, and even lack basic computer operation abilities. Due to the large number of students, teachers often pay their attention to imparting knowledge, using a single teaching method that lacks innovation and flexibility. In addition, time and energy are limited, making it difficult to provide one-to-one tutoring. Long-term listening and practice lead to some students being unable to keep up with the course progress in the classroom, feeling lost and unsure, resulting in learning difficulties and self-doubt, which affects the improvement of information application ability and is not conducive to the development of logical thinking and creativity cultivation. During the long-term learning process, students naturally further widen the gap between themselves and their peers, making the progress of students with weak foundations even slower and falling into a vicious cycle.

3.3.4 The teaching content is dull and uninteresting and the teaching effectiveness is poor

The current information technology teaching content focuses on imparting basic skills through text, images, and other means, while the cultivation of innovative thinking and practical abilities is somewhat insufficient,

resulting in students lacking innovative consciousness and practical abilities to adapt to future social development. Some course designs focus on traditional teaching materials taught by teachers, and students mechanically follow teachers' instructions and are required to complete a series of fixed tasks and exercises, without the opportunity to explore their own ideas or try different solutions. Often, they lack independent thinking ability in the learning process, which hinders the development of creative thinking. Knowledge and skills in the field of information technology need to be deeply understood and applied through practice, but some schools lack authentic and experiential practical teaching, or lack sufficient practical activities to exercise their practical skills. Students are helpless when facing practical problems, lack certain adaptability and innovation ability, and cannot effectively respond to complex technological challenges. In the era of rapid development of information technology, only those with innovative thinking and practical abilities can flexibly respond to various challenges in complex and changing work environments. Therefore, educators and school administrators need to re-examine the design and implementation of information technology courses, focus on cultivating students' innovative consciousness and practical ability, provide more opportunities for students to explore and practice independently, and promote their comprehensive development.

3.3.5 Teachers' inaccurate role positioning and weak sense of cooperation

In the new media environment, primary school students generally demonstrate strong independent thinking ability and exploratory spirit. They tend to seek solutions on their own when facing problems, showing a positive learning attitude and a strong desire for knowledge. Although this independence promotes individual growth to a certain extent, it also reflects a weak sense of cooperation. When students face difficulties or challenges, they are less willing to actively seek help and cooperation from teachers or peers, hindering the development of teamwork ability. The reason is that traditional teaching models usually center around teachers, emphasizing the authoritative position of teachers as knowledge exporters. This makes students play more passive receiver roles in the learning process, and their development depends on teachers' guidance and shaping. Although the role of a teacher has certain effectiveness in information dissemination and presentation of knowledge systems, it can lead students to overlook the importance of peer learning and limit their opportunities to gain knowledge and experience through collaboration.

3.3.6 The evaluation system is not yet perfect and home-school cooperation lags behind

The current evaluation system overly relies on teachers' judgment of exam scores and homework completion, forming an evaluation mechanism dominated by scores, with a single evaluation subject and unable to comprehensively assess students' abilities. When students pursue short-term scores, their learning attitude tends to become utilitarian, and they are prone to overlook long-term knowledge accumulation and practical ability improvement. The lack of assessment of students' practical operation and academic literacy also makes it difficult for teachers to obtain effective feedback in the teaching process, adjust teaching strategies in a timely manner, or provide targeted learning support. This information asymmetry hinders communication between teachers and students, further inhibiting the cultivation of students' innovative thinking ability.

To improve this phenomenon, schools and families need to establish a more comprehensive and diversified evaluation system. However, parents generally attach little importance to this field, and most parents have insufficient understanding of the importance of information technology, only staying at the basic level of use. They cannot deeply understand the core concepts, development trends, and applications of information technology, nor do they realize its key role in modern society and future career development. This cognitive deficiency makes it difficult for them to provide necessary learning resources and practical guidance for their children, directly affecting students' enthusiasm and participation in both in-class and out-of-class practices. It is difficult to solicit valuable opinions and suggestions from parents and form a systematic and normalized plan for the development and improvement of school information technology teaching activities. This phenomenon of poor interaction makes it

difficult for parents to timely grasp their children's learning situation in school, and to provide effective feedback on their children's learning progress and changes in interests.

4 The application of virtual digital human technology in primary school information technology teaching

4.1 Specific application cases of virtual digital humans in teaching

4.1.1 Virtual teacher: role playing and interactive teaching

Virtual teachers provide students with a new, convenient, and efficient teaching experience through vivid role playing, and are becoming a part of the digital education system with unique fun and infectiousness. For students facing the pressure of limited traditional classroom learning resources and inadequate digital literacy of real teachers, virtual teachers break through geographical limitations, integrate teaching resources, teaching spaces, and processes, and appear as friendly partners in intelligent Q&A and deep classroom interaction modes between teachers and students, forming three-dimensional interactive learning scenes, greatly reducing the threshold for practical operation of information technology courses, enhancing students' sense of learning participation and engagement, and effectively ensuring education equity.

Case: A remote primary school successfully introduced a virtual teacher system with government funding, truly achieving seamless integration with programming teaching. In the classroom, virtual teachers present themselves as realistic images of knowledge disseminators, learning partners, etc. to learners, presenting basic programming knowledge in an easy-to-understand way through vivid images, speech, and rich expressions, allowing learners to experience real-life learning scenarios through interaction with peers or teachers at any time. When students learn programming concepts such as variables, loops, and conditional statements, virtual teachers create teaching humanistic contexts through interesting examples and vivid situations to explain abstract concepts, and quickly adjust teaching content and difficulty to identify student confusion. Through various methods such as demonstrating code, real-time interaction, and answering questions, students can learn efficiently in real-time feedback, become active participants in learning, and enhance logical thinking and problem-solving abilities. Research has shown that in classes with virtual teachers, each student can learn at their own pace, significantly improve their programming comprehension ability, and enhance their learning interest, providing strong support for future education reform and digital transformation.

4.1.2 Teaching assistant: assisted learning and personalized recommendations

Combined with advanced technologies such as artificial intelligence and machine learning, virtual digital humans have shown unprecedented application prospects as teaching assistants. They help teachers manage information technology courses, and provide students with various practical teaching scenarios, practical training guidance, and personalized resource recommendations, allowing students to use highly secure practical opportunities to enhance their practical problem-solving abilities. They can also provide personalized learning advice and resource recommendations. Through highly intelligent algorithms and data analysis techniques, virtual digital humans can deeply analyze students' learning data, identify their learning styles, abilities, weaknesses, and strengths, and tailor personalized learning plans and consulting services for each student.

Case: In an experimental primary school, virtual digital humans use artificial intelligence to analyze students' information technology classroom performance, homework progress, test results, etc. Based on a comprehensive analysis of students' learning data, personalized learning plans are developed in combination with students' interests, goals, and potential to recommend more challenging questions for students with strong abilities and provide them with independent knowledge system construction space; set up flexible and diverse group cooperative learning methods for average students, mobilize their subconscious power, and use practical life situations to experience and verify problem answers, establishing a stable learning motivation for themselves; and provide auxiliary learning materials and specialized exercises that combine sound and painting for students with weak

foundations, promoting their integration of self-awareness and self-acceptance. Once students recognize individual differences, they can integrate and internalize knowledge through integration, transfer and apply it, form abilities, and accumulate literacy. Virtual digital humans adjust teaching content and methods in real-time based on students' feedback and learning progress. If students make significant progress in a certain stage of learning, virtual digital humans will update their teaching objectives in a timely manner and recommend higher-level learning resources. If students encounter confusion on certain knowledge points, virtual digital humans will provide additional guidance, helping students overcome obstacles in a real-time and targeted way. The flexibility and adaptability of virtual digital humans make them indispensable teaching assistants for teachers.

4.1.3 Data designer: production of online learning material and improvement of teaching effectiveness

While digital technology brings disruptive new formats, it inevitably prompts people to rethink the innovative role of virtual digital human technology in education, which helps people to have a more comprehensive understanding of the impact of technology applications on the production of online learning materials. The introduction of virtual digital human technology as a new tool promotes the development of highly-adapted personalized teaching models, combining various elements such as animation, audio, and video to design rich learning materials, bringing innovative changes to the online education industry. By recording professional explanations or inputting script copy to generate teaching videos, abstract concepts or complex operational processes of information technology are presented in the form of simulated animations, experiments, etc., improving the efficiency of short video content production, facilitating students' understanding of operating principles and steps, effectively meeting the diverse course needs of students, and enhancing teaching quality and efficiency.

Case: A teacher uses virtual digital humans to create teaching demonstration videos. Based on artificial intelligence technology, digital characters are generated to create real teaching scenarios. Complex information technology knowledge is automatically generated in various forms such as sound, animation, and video, and presented in a way that meets students' specific needs and is easy for them to understand. This allows students to solve complex or creative problems through human-computer interaction. Virtual digital technology adjusts teaching materials and optimizes teaching strategies in real-time based on students' feedback and learning progress, achieving personalized and refined teaching processes.

4.1.4 Practice participants: virtual laboratory and simulated scenario applications

Virtual simulation experiments are showing a booming trend in the field of digital education. By constructing simulation laboratories and scenes, students can acquire a three-dimensional interface that provides real-time feedback and interaction with the virtual world, allowing them to immerse themselves in and explore simulation objects for computer operations and skill training in a safe and controlled environment, without worrying about the privacy risks that may arise from real operations. The advantage of this application method is that it not only provides a learning platform for theoretical knowledge, but also extends practical operation opportunities to every student. In the virtual laboratory, students can freely explore, observe operational steps, and undergo repeated training in the virtual environment, thus deepening their understanding of computer operating principles and applications, and cultivating a sense of security and responsibility.

Case: A teacher uses a virtual simulation laboratory to conduct network security teaching. Students learn how to identify potential dangers such as phishing and malicious software through the virtual environment, understand the importance of personal information, and learn about protection measures. At the beginning of the course, students are introduced into the simulated Internet world. By extending the teaching time and space of different network scenarios, the teacher asks students to divide into several groups to identify unsafe links, emails and advertisements, and to identify and delete suspicious files, set strong passwords, encrypt data and conduct other operations anytime and anywhere until they master the operations. The teacher monitors students' repeated operations in real-time and provides immediate feedback. Through interactive practical teaching, students can

deepen their understanding of network security knowledge, and stimulate security awareness and information society responsibility in a secure and controlled environment, laying a solid foundation for future digital life.

4.2 The impact of virtual digital humans on students' learning outcomes

4.2.1 Improvement in learning interest and classroom participation

With the continuous emergence of new technologies represented by virtual digital humans, new opportunities have been brought to the field of education, enabling interaction between teaching environments and virtual characters. On the one hand, teachers convert the voice of virtual digital humans into various forms such as text, image, audio, and video, making classroom content more diverse and rich; on the other hand, virtual digital humans create efficient and interesting teaching environments with expressions and interactive methods that are close to the needs of real teachers and students, allowing teachers to guide and support students' efficient learning in immersive classroom scenes. Teachers use virtual digital humans to closely integrate teaching content with students' learning processes, based on real-time feedback systems to monitor students' learning status and progress at any time, and effectively supervise learning outcomes. Students are no longer mere knowledge receivers, but autonomous learners who send information and engage in real-time interaction with virtual digital humans through mobile phones or computers. Different interaction methods improve the speed and efficiency of information transmission, achieving barrier-free communication between students, digital humans, and teachers. This innovative teaching method not only attempts to build a close connection between teachers and students, but also effectively stimulates students' learning enthusiasm and creativity, enhancing the fun of classroom interaction experience.

A survey on virtual digital human teaching projects shows that virtual digital humans can efficiently complete courseware production, effectively shorten the production cycle and cost of online teaching videos, transmit knowledge and teach complex concepts through animations, 3D simulations, and other methods that are more closely related to students' lives, and stimulate students' curiosity and thirst for knowledge. Over 80% of students have significantly increased their interest in information technology courses. They are more willing to actively participate in classroom discussions and group activities, injecting strong technological momentum into improving the quality and efficiency of teaching.

4.2.2 Personalized learning evaluation and effectiveness of real-time feedback

Virtual digital human technology brings revolutionary innovation to learning evaluation and feedback through novel digital teaching methods, opening up a new immersive learning interaction mode. Its core lies in the ability to analyze students' learning performance, progress, and effectiveness in real time. With the help of powerful data intelligent processing and transmission, it provides accurate and personalized feedback that meets students' needs while taking into account their common and individual characteristics. Through multi-directional interactive feedback such as individual to individual, individual to group, and individual to environment, it understands the advantages and disadvantages of students' learning process, points out the direction for improving their abilities and literacy in the next step, and demonstrates the efficiency and pertinence of learning.

In the real-time feedback mechanism design of a virtual learning platform at a certain school, students can quickly identify and correct errors during the learning process without waiting for traditional homework grading and feedback. After students complete an online test or task, virtual digital humans immediately analyze the errors in their answers, provide specific explanations and correct solutions, and continuously record each student's answer accuracy, thinking patterns, and learning habits to form an accurate data path and generate personalized learning evaluation reports. Students combine their own weak points in information technology knowledge to find the necessary practice materials and learning resources in the corresponding categories for independent learning exploration. This is conducive to providing accurate guidance and tracking services for students' personalized learning. Teachers can also use this data and feedback to better adjust their teaching strategies, pay attention to

each student's unique needs, and achieve personalized teaching according to their aptitude.

4.2.3 Improvement in academic performance and learning satisfaction

It is clear that virtual digital human technology has a positive impact on students' learning by analyzing the academic performance and satisfaction of classes that utilize this technology for teaching.

Before implementing virtual digital human technology, a certain experimental school first collected academic performance and satisfaction data from participating and non-participating students respectively, in order to comprehensively obtain the real and overall cognition of students' learning performance and effectiveness. In the evaluation after implementing virtual digital human technology, the school compared and analyzed the academic performance of students who participated in the project and those who did not. The results showed that the average score of information technology courses for students who participated in the project significantly increased by 15%. This is not only a numerical increase, but also reflects that students can choose appropriate learning methods based on their own needs and interests to understand and apply knowledge according to their own ability development. At the same time, the satisfaction survey results also showed positive changes, with the satisfaction rating of participating students increasing from the initial 70% to 90%, indicating a significant increase in students' acceptance and identification with virtual digital human technology. Virtual digital humans create open, flexible, and compatible spaces for students, accurately assessing their learning status, process, and effectiveness to the maximum extent possible, promoting harmonious and autonomous resolution and development of their individual and common problems, and maintaining a high level of cognitive engagement in learning.

4.2.4 Brief summary

The application of virtual digital humans in primary school information technology teaching demonstrates multidimensional innovation potential, providing students with convenient and efficient learning experiences through vivid role playing and interactive teaching of virtual teachers, teaching assistants, data designers, and practice participants. Virtual teachers break through geographical limitations and enhance classroom participation through friendly partners; teaching assistants promote students' continuous exploration and improvement in practice through personalized recommendations; data designers utilize multimedia elements to create rich online learning materials, significantly improving teaching effectiveness; virtual laboratories provide students with a safe and controllable operating environment, inspiring their sense of information society responsibility. Not only does it allow students to focus more on the learning process and practical experience, but it also promotes academic achievement and learning satisfaction through personalized evaluation and real-time feedback, laying the foundation for education equity and quality.

With the rapid development of artificial intelligence and virtual reality technology, the virtual digital human industry has once again attracted widespread attention and demonstrated enormous application value. It adapts to students' learning needs in real time with higher levels of intelligence and deeper understanding ability, creating a realistic immersive learning experience that allows students to perform complex operations and experiments in a safe environment, providing new perspectives and methods for developing personalized teaching plans. In the future, virtual digital human technology will present trends such as cost reduction, diversified applications, and improved technological fairness in iterative upgrades. The investment of the government and enterprises will further expand, jointly promoting the rapid growth of the digital industry and injecting continuous momentum into education reform and development.

5 Strategies for information technology teaching reform in primary schools driven by virtual digital human technology

5.1 Improve infrastructure construction and accelerate technological innovation and investment

Improving infrastructure construction is the key factor to promote the application of virtual digital human technology. Modern education must rely on efficient and stable technical infrastructure, including high-speed

Internet connection, strong server support and flexible cloud computing platform, to support the real-time operation of virtual digital human technology, so as to ensure that teachers and students can use virtual digital human avatars to carry out various immersive interactive real experiences beyond reality. Local education administrative departments provide financial support to schools to help them introduce and maintain virtual digital human systems, and develop corresponding training plans to enhance teachers' technical application capabilities. Educational institutions analyze and evaluate existing technological infrastructure, identify potential shortcomings, and develop corresponding improvement plans. Schools and educational technology enterprises establish close cooperative relationships to jointly develop virtual digital human teaching systems that meet the actual needs of students. Through continuous improvement and optimization of infrastructure, the education industry can better utilize technological means to create personalized, innovative, and situational tutoring teaching, create a new model of digital learning shared between urban and rural areas, and enhance education equity and quality.

However, in the context of the current global wave of metaverse, it is difficult for virtual digital humans to achieve infinite proximity to the real natural state of humans. One of the main reasons is that there are barriers to data interconnection between different systems and platforms, which not only affect the flow of teaching resources but may also lead to a decrease in teaching effectiveness. When teachers import rich teaching resources such as courseware, micro-lessons, and interactive materials produced on virtual digital human platforms into learning management systems, they often encounter compatibility issues. Due to the possibility of using different data formats, storage structures, and API interfaces between these two systems, the data cannot be smoothly integrated during the transfer process, resulting in virtual digital humans being unable to provide much surprising experience to teachers, students, and users in the metaverse. To address this issue, educational institutions and technology developers need to increase their investment in technology research and development. By developing more universal standards and interfaces, virtual digital humans can break free from compatibility constraints and have universal commercial value in terms of stability and intelligence.

5.2 Promote the transformation of teachers' roles and strengthen professional development training

Virtual digital human technology endows teachers with new connotations in their role by simulating the unique advantages of human language, thinking, and behavior. Teachers have transformed from traditional knowledge transmitters to students' learning guides, which has had a profound impact on traditional education models and the re-examination and planning of career development paths. Setting specific and clear learning goals has gradually become the primary learning task for students. In the new curriculum reform, content standards are the core part of the new curriculum standards. Teachers should strictly adhere to the requirements of the content standards to fully explore the potential value of digital human technology and the characteristics of information technology disciplines. Through data analysis, they should design teaching goals that are appropriate for students' actual situations and have rules to follow. Based on students' experience system, individual differences, and future development, AI intelligent recognition and interactive systems should be used to carry out teaching activities that are in line with the growth laws of each student, focusing on students' zone of proximal development, and ensuring that the learning process becomes a process of students' sound personality development. This role transformation requires teachers' professional development training to constantly adapt to the application of new technologies in order to improve the quality of education and teaching.

In order to truly implement virtual digital human technology in teaching scenarios and meet the diverse training needs of teachers, first of all, schools need to create a walking training classroom for teachers, realizing multi-device collaboration, cross-screen sharing operation and other training equipment usage scenarios, as well as diversified online and offline training methods. They should provide skill training courses covering the operation methods of virtual teacher systems, personalized learning plan settings and adjustments, etc., to meet teachers'

precise grasp of how virtual digital humans can serve educational and teaching needs, and effectively help teachers achieve digital upgrading in various teaching links such as pre-class preview, in-class learning, and post-class review. Secondly, training in teaching methods plays a crucial role in the professional development of teachers. It's necessary to enable teachers to have a deep understanding of the basic principles and application scenarios of virtual digital human technology, including exploration of the technology itself and its potential and advantages in education, and to understand how to use virtual digital humans as auxiliary teaching tools to better assist teaching and enhance students' learning outcomes and interests through successful teaching cases. When designing comprehensive teaching activities, virtual digital humans are combined with traditional teaching methods to create a highly interactive and participatory learning environment. The presentation and interactive content of virtual digital humans are adjusted according to the learning needs and styles of students based on individual differences, to ensure that every student can truly become an active knowledge builder in the new learning mode. Thirdly, the training provides interactive workshops that simulate classroom scenes through virtual simulation technology, allowing teachers to experience the interaction between virtual digital humans and students with different individual differences in various realistic scenarios, inspiring students to optimize the learning process and learning outcomes. Finally, schools should strengthen the construction of online learning platform systems, provide continuous learning support and abundant resources for teachers, promote differentiated and interactive experience exchange, form learning spaces suitable for the development needs of teachers' professional qualities, create more diverse and abundant learning experiences for students, and effectively play the role of digital human technology in promoting teachers' professional development.

5.3 Design diversified teaching content and carry out interactive teaching

Virtual digital human technology provides comprehensive and convenient services for diversified teaching content design in the field of information technology education. By analyzing students' learning data and individual differences, teachers can create personalized course modules that adapt to different learning styles and cognitive levels. With graphic animations and real-time examples, dynamic video explanations and interactive dialogue exercises are designed for visual learners, prompting students to use self-explanation strategies to improve their video learning effectiveness. It is also possible to simulate real-life scenarios and set role playing tasks in different situations in the teaching content, promoting students to try to develop diverse communication strategies and skills, and enhancing teamwork and problem-solving abilities.

This flexible and innovative content design not only promotes students to fully utilize their inspiration and thinking abilities to stimulate their creativity in actively participating in cognitive practice activities, but also brings tremendous changes to the development of high-frequency interactive teaching models. Virtual digital humans restore the virtual 3D scenes recorded in textbooks, and interact in real-time with students of different skill levels through questioning, discussions, group activities, and character dialogues. They guide each student to collaborate, explore, and operate in a safer and more efficient immersive environment, personally experience the process of generating teaching content, enhance learning interest and participation, deepen understanding and application of information technology knowledge and skills, and adapt to future social development.

5.4 Optimize the education evaluation system and establish a mechanism for home-school interaction and cooperation

The dynamic changes in students' growth process inevitably limit their development with the traditional standardized evaluation system. Schools should analyze and organize the existing student comprehensive literacy evaluation system based on comprehensive evaluation needs, classify and refine evaluation indicators, develop evaluation plans, and create a diversified evaluation system for innovative education to comprehensively reflect the progress and performance of students' information technology learning. Firstly, with the digital foundation as the core, a formative evaluation method is adopted, focusing on every progress and interaction in students' learning

process. Digital human technology captures students' daily management data from multiple dimensions, and teachers conduct comprehensive evaluations of students' social practice, academic literacy, ideological and moral performance, generating clear and intuitive student growth reports in the form of charts. Ultimately, students' growth portrait scene is constructed to help them clarify their own strengths and weaknesses in development. Stereoscopic portraits enable education to no longer rigidly change students, but to comprehensively and objectively view each student based on their performance, achievements, and reflections in the process of information technology learning, ensuring that all students continue to move forward on their personalized growth path. Secondly, encourage students to conduct self-evaluation and peer evaluation, quickly analyze their shortcomings, and improve their overall level of information technology application in a targeted manner, cultivating their reflective ability and critical thinking.

On this basis, home-school collaboration is an indispensable part of the information technology education process. The active participation of parents can provide students with good learning support, influencing and improving their information technology learning environment. Schools should regularly hold training classes for parents to introduce virtual digital human technology and its application in teaching, so that parents can adapt to the school's teaching mode more quickly and understand the promoting effect of technology on information technology curriculum content, fully awakening students' learning consciousness. Design information assignments that are suitable for the family environment, encourage parents and students to participate in learning activities together, establish effective communication and feedback mechanisms using virtual online platforms and social media, regularly provide feedback on students' learning progress, inspire parents to further consider the reasons for students' underperformance and develop corresponding improvement plans, form a positive interaction mechanism between online and offline home-school cooperation, and provide strong guarantees for students' healthy growth.

As an innovative practice in the education industry, virtual digital human technology still faces some challenges in its application in education and fairness with the continuous expansion of its promotion scope. Measures need to be taken from the aspects of technological innovation, training empowerment, improvement of educational content and methods, and optimization of evaluation mechanisms. In the future, virtual digital humans will present features such as multi-user interaction, multi-modal learning experience, and personalized adaptive learning driven by data. Its introduction is not only a technological innovation, but also an important driving force for promoting the reform of primary school information technology teaching. In order to better integrate it into the application of information technology education, we need to focus on students' needs, improve the level of personalized, intelligent and smart education, enable new technology services rather than controlling the quality of education, promote education equity and rational allocation of resources, and create a better learning environment for the development of students' core competencies.

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