A Study on the Construction of Virtual Simulation Teaching Platform for Preschool Inclusive Education in the Digital Context

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Abstract: Amid educational digitization, preschool inclusive education faces homogenized training, high logistical costs, and inadequate teacher competency. This study designs and validates a Virtual Simulation Teaching Platform through literature review, needs assessment, and iterative development, establishing a "trinity" framework integrating internship simulation, post-service professional development, and competency evaluation. Comprising practical operation, data acquisition, and operational assessment subsystems, it mitigates the "three highs and three difficulties" inherent in traditional pedagogy (high investment, complexity, and risk; difficulty in implementation, observation, and reproduction). Empirical results show that the platform optimizes talent training models, improves students' practical efficacy and teacher competency, providing a scalable technical path for the high-quality development of inclusive education.

***Keywords*:** digital transformation; preschool inclusive education; virtual simulation; talent cultivation; pedagogical reform

1. Introduction

1.1 Problem Statement and Context

Inclusive education serves as a critical metric for educational equity and social progression, mandating high-quality opportunities for children with heterogeneous needs. As the foundational stage, preschool inclusive education is pivotal for the longitudinal development of special needs children. However, the domestic landscape in China is beleaguered by structural dilemmas[1]. Traditional practical teaching models are constrained by static training scenarios, prohibitive off-campus costs, and safety protocols that relegate learners to passive observation, thereby stifling the acquisition of operational skills. Concurrently, the professional competence of the teaching workforce exhibits significant variance, exacerbated by a dearth of effective post-service training and standardized assessment mechanisms[2].

The proliferation of digital technologies—specifically the immersion, interactivity, and repeatability afforded by virtual simulation—provides a potent remediation to these systemic rigidities. With the Ministry of Education explicitly advocating for the "deep integration of information technology and education," a strategic window has emerged for constructing high-fidelity virtual simulation platforms tailored to this domain.

1.2 Theoretical and Practical Implications

Theoretically, this study augments the epistemological system of preschool inclusive education by embedding virtual simulation into the pedagogical framework. It clarifies the theoretical connotation of digital interventions and proposes a "trinity" model that spans the professional lifecycle, enriching the discourse on talent cultivation[3].

Practically, the platform offers a decisive intervention against the "three highs and three difficulties". By migrating high-risk, resource-intensive scenarios into a controlled virtual environment, the system substantially lowers the barrier to entry for practical training while enhancing repeatability[4]. Furthermore, it establishes a novel pathway for the professional development of in-service teachers, facilitating the acquisition of technical and pedagogical competencies independent of physical constraints[5].

1.3 Literature Review

The integration of virtual reality (VR) in education is well-documented globally. In preschool contexts, international scholars have leveraged VR to simulate kindergarten environments for classroom management drills. Specific to inclusive education, research has focused on simulating interventions for special needs children, with recent studies confirming that VR interventions significantly bolster preservice teachers' self-efficacy and management skills[6][7].

While domestic research has accelerated, a critical gap persists regarding platforms specifically tailored for inclusive

education[8]. Existing solutions predominantly target general preschool education, lacking the specialized design required for special needs scenarios[9]. Moreover, prevalent platforms often suffer from fragmented content and a disconnect between technological capability and pedagogical utility[10]. This study seeks to bridge these gaps by offering a cohesive, targeted, and empirically evaluated solution.

1.4 Methodology

To ensure methodological rigor, this study adopted a multi-faceted approach:

(1) Literature Research: A systematic review of domestic and international literature to establish the theoretical grounding.

(2) Needs Assessment: Utilization of questionnaires and interviews to conduct a gap analysis regarding the needs of professionals and teachers.

(3) Iterative Paradigm: Adoption of an iterative development model to continuously refine platform functionality based on user feedback cycles.

(4) Empirical Evaluation: A multi-dimensional assessment employing classroom observation, skill quantification, and surveys to validate pedagogical efficacy.

2. Theoretical Foundation and Demand Analysis of Platform Construction

2.1 Conceptual Definitions

Preschool Inclusive Education is defined as the integration of children with special needs (e.g., ASD, physical disabilities) into mainstream kindergartens, supported by personalized interventions to promote equity and integrated development. The Virtual Simulation Teaching Platform represents a digital ecosystem integrating VR, AI, and big data to construct high-fidelity environments for risk-free practice, skill acquisition, and competency evaluation.

2.2 Theoretical Underpinnings

The platform's architecture is anchored in three pedagogical theories:

(1) Constructivism: Positing learning as active knowledge construction, the platform provides an interactive environment where learners build professional schema through direct experience.

(2) Situated Learning: Emphasizing context-dependent acquisition, the platform simulates the complexity of inclusive classrooms, requiring learners to solve authentic problems within specific situational constraints.

(3) Digital Education Theory: Advocating for technology as a core pedagogical support, this theory operationalizes the use of digital tools to optimize instructional efficiency and resource distribution.

2.3 Needs Analysis

The imperative for this platform stems from three critical deficits:

(1) Talent Cultivation: The disconnect between theory and practice necessitates diverse, realistic training environments to facilitate the transition from conceptual knowledge to operational capability.

(2) Professional Development: In-service teachers require accessible, efficient post-service training to update educational paradigms and master intervention strategies.

(3) Resource Allocation: There is a pressing need to integrate and share scarce high-quality educational resources to promote balanced industry development.

3. Construction of Virtual Simulation Teaching Platform for Preschool Inclusive

3.1 Objectives

The overarching objective is to engineer a "trinity" platform integrating internship training, post-service development, and competence assessment. This system aims to enhance student employability, facilitate teacher professional growth, and establish a standardized metric for talent evaluation.

3.2 Logical Architecture

The platform adopts a robust three-tier architecture:

(1) Infrastructure Layer: The foundational hardware (servers, VR sensors) and software (Unity3D, AI algorithms) providing technical viability.

(2) Core Function Layer: Comprising the Practical Operation, Data Collection, and Operation Evaluation systems.

(3) Application Service Layer: The user interface enabling access across PC and mobile terminals for diverse user roles.

3.3 Core Functional Modules

3.3.1 Practical Operation System

Designed to circumvent the "high risk" and "irreversibility" of in-situ practice, this system integrates curricula such as Behavior Modification.

(1) Environmental Simulation: Constructs dynamic, high-fidelity ecosystems (e.g., sensory rooms). Users can manipulate variables, such as the "quiet corner" layout, to analyze environmental impacts on social interaction.

(2) Scenario Simulation: Facilitates Emergency Interventions (e.g., managing ASD meltdowns via Positive Behavior Support) and IEP Implementation in mixed-ability classrooms, allowing for risk-free repetition of differentiated instruction.

(3) Project-Based Training: A tiered progression from Basic Skills (ABC analysis tools) to Professional Skills (inclusive game design) and Comprehensive Ability (full-cycle assessment and home-school communication).

3.3.2 Data and Evaluation Systems

The Data Collection System functions as a centralized repository for teaching resources while performing real-time acquisition of user behavioral data for analytics. Complementing this, the Operation Evaluation System utilizes a comprehensive question bank and diagnostic algorithms to generate real-time assessment reports and issue electronic certification.

3.4 Technological Integration

The platform leverages Virtual Reality (Unity3D) for immersive rendering, Artificial Intelligence for intelligent tutoring and adaptive behavioral simulation of special needs children, and Big Data for mining learning patterns to inform pedagogical optimization.

4. Practical Application and Effect Evaluation of the Platform

4.1 Study Design

To validate pedagogical efficacy, a pilot study was conducted involving 200 preschool education students from Qingdao Binhai University and 50 in-service teachers from the Qingdao region over a 6-month intervention period.

4.2 Results Analysis

Quantitative analysis via paired-samples t-tests revealed significant improvements across all metrics (Table 1).

Table 1. Comparison of Differences in Professional Competence Before and After Application

Variables	Group	Pre-test	Post-test	t	p	Cohen's d
Student Professional Knowledge	N=200	73.30±12.50	85.60±11.20	13.92	<0.001	1.03
Student Practical Ability	N=200	66.60±13.15	82.30±10.80	17.08	<0.001	1.3
Teacher Competence	N=50	76.30±10.40	86.80±9.50	7.42	<0.001	1.05

4.2.1 Student Learning Outcomes

The intervention yielded a statistically significant enhancement in Professional Knowledge ($t=13.92$, $p<0.001$), with the pass rate reaching 98.5%. The substantial effect size ($d=1.03$) suggests the immersive modality outperforms traditional instruction. Most notably, Practical Operation Ability demonstrated a robust increase ($t=17.08$, $d=1.30$), confirming that the virtual environment effectively bridges the theory-practice chasm, particularly in complex intervention scenarios. Additionally, 92% of students reported perceived improvements in comprehensive soft skills.

4.2.2 Teacher Development and Operational Stability

In-service teachers exhibited a significant shift in pedagogical paradigms, with 90% reporting a transition from segregationist views to inclusive philosophies. Competence scores rose significantly ($t=7.42$), driven by targeted modules such as IEP design. Classroom observations confirmed the transfer of virtual skills to real-world settings, evidenced by improved responsiveness to emergencies. The platform demonstrated high stability (response time <2s) and achieved a 90% user satisfaction rate.

5. Problems and Optimization Strategies in Platform Construction

5.1 Existing Problems in Platform Construction

5.1.1 Insufficient Richness of Simulation Scenarios

Although the platform has constructed a number of preschool inclusive education simulation scenarios, the types and

quantities of scenarios are still insufficient, and it cannot fully cover all aspects of preschool inclusive education teaching. Some special and complex teaching scenarios are not involved, which restricts the improvement of users' comprehensive practical ability.

5.1.2 Need for Further Optimization of Technical Support

The platform's technical support still needs to be further optimized. For example, the compatibility of the platform with some virtual reality terminals is not good, and there are problems such as screen jitter and poor sound quality during the use process. In addition, the platform's data security and privacy protection measures need to be further strengthened to prevent user data leakage.

5.1.3 Imperfect Long-term Operation Mechanism

The platform's long-term operation mechanism is not perfect, including the update and maintenance of platform resources, the training of technical and teaching personnel, and the sustainable development of the platform. If these problems are not solved, it will affect the long-term stable operation and continuous improvement of the platform.

5.2 Platform Optimization Strategies

5.2.1 Enrich the Types and Quantities of Simulation Scenarios

Based on the feedback of users and the actual needs of preschool inclusive education, we will increase the development efforts of simulation scenarios, add special and complex teaching scenarios, such as the education and guidance of children with severe disabilities, the coordination and cooperation between inclusive education and special education institutions, and so on. At the same time, we will continuously optimize the existing scenarios according to the changes in preschool inclusive education policies and teaching practices to improve the authenticity and applicability of the scenarios.

5.2.2 Strengthen Technical Support and Optimization

Strengthen the technical research and development and optimization of the platform, improve the compatibility of the platform with various virtual reality terminals, solve the technical problems such as screen jitter and poor sound quality. At the same time, establish a sound data security and privacy protection system, adopt advanced data encryption technology and security management measures to ensure the security and privacy of user data. In addition, set up a special technical support team to provide timely and effective technical support and maintenance services for users.

5.2.3 Improve the Long-term Operation Mechanism of the Platform

Establish a sound long-term operation mechanism of the platform, including:

(1) Establish a resource update and maintenance mechanism, regularly update and supplement the platform's teaching resources, and ensure the timeliness and richness of the resources;

(2) Strengthen the training of technical and teaching personnel, improve their professional competence and service level, and provide strong personnel support for the operation of the platform;

(3) Explore a sustainable development model of the platform, strengthen cooperation with colleges and universities, kindergartens, and enterprises, expand the source of funds and resource channels of the platform, and ensure the long-term stable operation and continuous development of the platform.

6. Conclusion and Outlook

6.1 Conclusion

This study successfully engineered and validated a virtual simulation teaching platform that effectively dismantles the "three highs and three difficulties" characterizing preschool inclusive education. The "trinity" framework has proven instrumental in meeting the diverse needs of stakeholders, delivering statistically significant improvements in knowledge acquisition, practical proficiency, and professional competence.

6.2 Future Outlook

Future research will expand the geographical scope to test generalizability, refine evaluation metrics for longitudinal tracking, and deepen the integration of AI to foster true adaptive learning. Through international collaboration and continuous optimization, this platform is poised to become a cornerstone in the high-quality, digital transformation of inclusive education.

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