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The Role of Virtual Reality in Teacher Education Programs

Dr. Sonam Sharma
Assistant Professor, Department of Education
Km. Mayawati Government Girls P.G. College, Badalpur, G.B. Nagar.(U.P.)
Email:- sharmagaura195@gmail.com

Abstract:

The use of innovative technologies in teacher education and training is becoming increasingly important as digital natives enter schools. Virtual reality (VR) allows trainees to engage in practice as if they were actually teaching. Research on VR-based teacher training and education is still scarce, with a few studies focusing on skill acquisition, enhancement, and development. Some studies demonstrate the potential of VR in professional education, including teacher training, but more empirical data is needed to quantify its effects more broadly. Studies exploring VR for teacher education are growing, although no systematic literature review yet exists. Interest in VR is rising as educators seek novel solutions to enhance professional pedagogy (Evangelia Stavroulia & Lanitis, 2019).

Teachers spend a substantial amount of time interacting with students throughout their careers, indicating that their competencies largely shape student learning. Emerging competencies needed to address new educational challenges include micro-teaching, curriculum differentiation, and inclusive education. Adopting new VR software in teacher education could better equip trainee teachers with next-generation competencies and skills while allowing room for improvement in existing training systems (Ke et al., 2021).

Keywords: Innovative technologies, Virtual reality(VR), Teacher education.

1. Introduction

Teaching is a profession that requires extensive preparation and training. Teacher preparation programs are designed to provide prospective teachers with training in the skills and knowledge they will need for the classroom. Programs are often multi-faceted, with a variety of courses to

learn theoretical content, subject area knowledge, and pedagogy and practice. In addition to course work, teacher preparation programs also include an in-service component, known as student teaching, which allows prospective teachers to practice their skills. The complexity of teaching means that even extensive preparation cannot entirely prepare prospective teachers for the realities they will face. Research shows that some teachers feel unprepared to teach a wide range of subjects, use specific teaching strategies, or manage classroom behavior (Ke et al., 2021). The complexity of teaching also means that strong skills do not always translate into success. Teachers frequently encounter situations in the classroom that they had not anticipated. Whether at the time of preparation or after becoming a teacher, a more authentic and effective means of training is desirable.

Virtual reality (VR) offers a potential solution to these challenges. VR is defined as any interactive computer-generated experience in a real or imagined environment that occurs in real time. VR simulations are variations of computer-enhanced learning environments or serious games (Evangelia Stavroulia & Lanitis, 2019). Through the use of VR, prospective teachers can practice classroom management, pedagogical methods, and culturally sustaining practices in a scenario that simulates real classroom conditions. A prospective teacher can design lesson plans for a particular class, set of students, and topic and be placed in a classroom with 1, 5, 10, or 30 simulated students who react according to the plan, materials, and flow of the lesson. Prospective teachers in such VR environments have easy access to in-the-moment feedback and can build authentic skill sets through the same means they learn when becoming unnecessarily formal. Computer-based settings encourage flexible engagement before moving toward higher fidelity tasks and environments (Ke et al., 2021). Simulated environments permit authentic engagement through authentic subject matter, materials, rhetoric, and engagement. Simulated environments open space for prospective teachers to gain experience without the risks attached to complex and non-routine explorations in traditional environments.

2. Theoretical Foundations of Virtual Reality in Education

Researchers and practitioners recognize the need to equip teachers with pedagogical and social skills to address the diverse educational needs of their students. This objective is complicated in two respects. First, individual students in classrooms often display diverse behavioral needs and educational requirements associated with factors such as their native language, socio-economic status, sexual orientation, or disability. This challenge is harder to solve for teachers who have not yet obtained their own teaching license. Consequently, a prominent focus of teacher education today revolves around how to support new teachers in providing tailored educational interventions that meet the specific requirements of students in their individual classrooms (Evangelia

Stavroulia & Lanitis, 2019). Second, the traditional methods employed in many teacher-preparation programs—written case studies or discussions of classroom-teaching situations encountered in the past, for example—do not afford trainee teachers realistic and immersive opportunities to practice the skills they would be required to deploy in an actual classroom setting. Considerable interest in using simulation-based approaches, therefore, has emerged in recent years in an effort to allow trainee teachers to prepare directly for diverse and multicultural classroom settings, both before they obtain their teaching license and later in their careers (Ke et al., 2021). When practitioners and researchers endorse simulation-based training, they frequently view VR technology as a plausible option because it enables the development of virtual scenes and actors that constitute effective substitutes for real classroom settings.

2.1. Immersive Learning and Cognitive Engagement

Immersion, presence, cognitive load, and engagement are critical concepts in educational virtual reality (VR) (Gordon & Brayshaw, 2017) ; (Reiners et al., 2014). Immersion is a multi-sensory phenomenon where content engages multiple cognitive channels, the learner experiences a virtual world and feels detached from the real world. Presence is the mental state resulting from immersion (Peisachovich et al., 2021). Cognitive load, arising from content and interface, influences learning. Engagement signifies the degree of attention devoted to content; it originates from intrinsic, social, and temporal aspects and is intimately connected to knowledge acquisition. Conceptions of immersion vary, yet its core notion remains constant. The content-richness-immersion-engagement-learning process can differ but generally follows the same principles.

2.2. Constructivist and Experiential Learning Theories in VR

School experiences shape beliefs and know-how, but exposure can be limited (Peisachovich et al., 2021). VR enables practice within a safe digital space, fostering authentic environments and situated cognition (Bahng & Lee, 2017). The technology facilitates scenarios that address classroom management, pedagogical skills, and culturally responsive strategies.

Different VR platforms enable various practices. Simulations can immerse participants in large classes, enabling them to establish authority through commonly observed openings. Opportunities to complete foundational routines provide formative assessment and focus feedback on management layers. Implementing methods like differentiation or assessment in virtual scenarios and reviewing recordings promotes reflective engagement.

Culturally responsive practice is essential for inclusivity. VR can enhance accessibility, address bias concerns, and encourage universal design. Potentially uncomfortable situations in hypothetical scenarios allow exploration of real-world challenges in safe spaces, fostering alternative perspective-taking and demonstrating systemic inequities.

3. Practical Applications of VR in Teacher Preparation

The phenomenon of Virtual Reality (VR) is rapidly being introduced in teacher education programs as institutions position themselves to embrace and adopt the changing technology landscape, especially with the increasing prevalence of online education. VR has emerged as a practical approach for teacher preparation across the globe since it allows user-friendly mobility in simulated classroom environments, bridges the gap between coursework and practice, and inspires the adoption of constructivist pedagogy. It has gained momentum since its introduction to teacher preparation programs in Hong Kong in 2020 and its adoption in Melbourne in 2021. The practice of using full-immersive technology garners more support each day.

3.1. Classroom Simulation and Classroom Management

Virtual Reality (VR) technology applied to classroom instruction can also support teacher education programs using virtual teaching environments to simulate real classroom scenarios. Multiuser applications allow simultaneous participation by multiple student teachers in instructor roles with avatars representing students. Scenarios depict common situations that arise in classrooms, and participants select appropriate strategies to manage events. Feedback from the simulated students is provided by the system according to the instructor's actions, and the instructor can review video of the simulation (Ke et al., 2021). An additional VR utility permits teacher educators to experiment with instructional design, learning theory, and strategies for adaptive assessment for lesson planning.

VR simulations represent a valuable tool to assist teacher educators preparing pre-service teachers to build classroom management skills. Classroom management refers to activities that establish and maintain the classroom environment conducive to instruction and learning. It encompasses an array of capabilities, such as initiating learning activities, maintaining momentum, handling inattention and disruption, and managing the exit or transition from an activity; classroom management activities can occur prior to, during, or after the delivery of learning tasks. Acquisition of classroom management skills is critical, especially for novice teachers, yet opportunities to practice in real classrooms remain limited.

3.2. Pedagogical Skill Development and Assessment

The pedagogical skill development and assessment VR application targets specific in-service competencies concerning student differentiation and formative assessment (Ke et al., 2021). Pre-service teachers can create lessons for diverse learners tailored to their characteristics and needs, whilst formative assessment, designed to gather evidence for next-step planning, can be practised through means tailored to groups and individuals. The assessment of these two components, alongside the selection of instructional strategies, constitutes an explicit reflection exercise

integrated into the nonlinear flow of an immersive VR loop (Evangelia Stavroulia & Lanitis, 2019). In developing individual lessons aligned to these two capabilities, pre-service teachers develop and enhance the ability to thoughtfully consider pedagogical and assessment decisions after an initial lesson design, mirroring expert consultations in person.

3.3. Cultural Responsiveness and Inclusive Practice

Among the many paradigms of effective teaching, Culturally Responsive Teaching (CRT) is emerging as a critical approach in today's multicultural societies. Culturally Responsive Teaching (CRT) develops various dimensions of a teacher's practice that are culturally, socially, and politically relevant to learners and their communities. Research shows that teacher biases—whether conscious or subconscious—can negatively impact student achievement and current teacher education programs fail to adequately develop pre-service teachers' understanding of, and capacity to delivery Culturally Responsive Teaching (Evangelia Stavroulia & Lanitis, 2019).

A synthesis of existing literature identified six key ideas or learning objectives fundamental to Culturally Responsive Teaching that VR could potentially address in a pre-service framework. They are: (1) starting from what learners already know; (2) considering the elements of multicultural education to include; (3) analysing culturally relevant curriculums used in predecessors' lessons; (4) being acquainted with learners' abilities, cultures, knowledge, and understandings; (5) aiming to construct connection/cross between what learners already know and their ideas and thinking; and (6) developing awareness of multimedia resources to include in a lesson to make it interesting and enter students' life, people and surroundings (Peisachovich et al., 2021).

4. Evidence from Empirical Studies

In exploring the impact of VR in teacher education, Huerta (2022) provides credible evidence through empirical studies of VR-in-the-loop simulation-based training (VBST) for novices that involve pre-service teachers enacting classroom scenarios resembling yet differing from their own experiences. Scale-up studies with diverse cohorts from 2019 to 2021 further corroborate that VR-based pedagogy enables effective development and transfer of teaching competencies and pedagogical content knowledge (PCK) for college and K–12 instructors (Ke et al., 2021) while enhancing reflective practices, diverse pedagogical approaches, and cultural responsiveness for in-service teachers at the university level (Evangelia Stavroulia & Lanitis, 2019). Teacher confidence and preparedness measures indicate substantial positive changes after participation in VR-PBL. The timing of these changes, discerned from post-course and follow-up surveys, reveals that instructors observe significant gains before taking their first individual teaching position. Institutional barriers to program implementation relate largely to the perceived costs of VR

technology despite the availability of low-budget tools that could enable scaling with appropriate training and pedagogical models. Considerations in this domain must address foundational requirements such as the acquisition of VR hardware and software and access to training for design and development. Transparency about both institutional and technical prerequisites could facilitate closer examination of VR at higher institutional spheres, leading to deployment in teacher education.

4.1. Learning Outcomes and Skill Acquisition

Advances in virtual reality (VR) technology have opened new avenues to prepare future educators for the classroom environment. A systematic review has concluded that educational VR supports skill acquisition and knowledge retention to the same extent as educational theories and teaching pipelines found in conventional preparation programs (Ke et al., 2021). In VR environments, participants approach the lesson-flow cycle through determining the lesson context and objectives, designing assessment tools, instructional strategies and materials, and providing actionable, multi-faceted feedback (Evangelia Stavroulia & Lanitis, 2019). Even though still emerging, VR continues helping teachers reflect upon and improve their instructional practices, ultimately making better connections with students. At last, teacher skills and competencies development is indispensable for teacher training institutions and establishments guaranteeing the quality of education.

The effectiveness of VR-based teacher preparation programs is on the same level with traditional teaching theoretical frameworks and Keller´s ARCS motivational strategies. Elementary education undergraduates seem to achieve similar, if not higher, instructional skillsets and subject matter knowledge when exposed to the VR environment, notwithstanding the academic broadcasted news compared to upcoming training facilities of future job-students. Fully possessing adequate subject-matter knowledge for elementary school teaching appears very appropriate for instructors use. A non-annual online instructor-training program fosters teachers´ capacity to have more individual face time with teaching-trainees of pedagogical marvel-topic-trains.

4.2. Teacher Confidence and Preparedness

Simulation-based training enables learners to practice skills and strategies in a realistic environment and receive feedback about their performance. For preservice teachers, learning opportunities that truly support progressive development of effective classroom management skills are limited. Classroom Management VR (CMVR) aims to fill this gap. CMVR is a multiuser virtual setting where preservice teachers engage in real-time 3-D classroom management simulation. Users create 3-D geometries of students, teachers, classroom layouts, instructional

materials, and other relevant factors, allowing for practical scenario design before entering a simulated classroom. Each scenario can include a variety of multimedia instructional resources such as video clips, audio files, and images, together with preliminary and follow-up questions. Furthermore, CMVR facilitates peer feedback and reflection through text essays, teacher supervision, and whole-class discussions, thus providing preservice teachers with additional means of self-reflection (Ke et al., 2021).

VR, an immersive and interactive technology with potential to enhance empathy and reflective teaching through simulated classroom experiences, is emerging in teacher education. Addressing pressing needs for practice opportunities, VR offers a safe, low-cost platform for practicing teaching skills without risk to real learners. VR teaching simulations enable recording, reflection, and revision of performance. Trainees can rehearse lessons, manage challenging behaviors, and gain insight into pupils' perspectives. VR scenarios foster professional development by confronting trainees with specific risks and affordances of classroom technologies, enhancing preparedness for diverse and complex classroom contexts (Evangelia Stavroulia & Lanitis, 2019).

4.3. Equity, Access, and Barriers to Implementation

Virtual Reality (VR) systems can be costly and require hardware, software, and an appropriate physical environment. Implementing VR approaches necessitates developing educational arguments and practical constraints. Other impediments include the digital divide, which prevents access to VR technologies in under-resourced institutions, and policies requiring pre-approval for adopting new technologies. Additionally, deploying VR as immersive educational technology often requires training in VR pedagogy and creating actual 3D scenarios. Teacher education is not yet aligned with rapid technological advancements. New capabilities such as blockchain, artificial intelligence, robotics automation, data ethics, and transcription are emerging, but comprehensive training is lacking to close the gap (Bahng & Lee, 2017) ; (Gordon & Brayshaw, 2017).

5. Technical and Pedagogical Considerations for Programs

For teacher education programs, developing technical and pedagogical frameworks can ensure that virtual reality (VR) experiences meet the requirements of immersive learning and include pedagogically sound guidelines for integration into curricula.

Successful VR experiences require established hardware and software components that maintain immersion and utilize appropriate teaching and learning strategies. High-quality VR training programs also require a detailed understanding of instructional design models and how to modify content within a given model. In some cases, trade-offs may exist between system fidelity and generalizability of scenarios and pedagogy, influencing whether full-system designs or narrowly defined components are assembled. Guidelines for the development and adaptation of VR training

programs include principles for content design, instructional differentiation, reflective professional development, and the integration of student feedback into teacher education.

Recent studies suggest that the temporal dynamics of VR experiences may be a key consideration in curriculum design. Preliminary evidence indicates that specific VR content and pedagogy can engage students in deep, sustained immersive learning; counterproductive classroom management applications, in contrast, can cause shallow engagement and distracted attention (Ke et al., 2021). Integration of VR experiences into broader preservice teacher education curricula is therefore crucial (Evangelia Stavroulia & Lanitis, 2019). Multiuser, multi-context VR systems may furnish new opportunities for situated teaching practice and knowledge construction alongside other modes of pedagogical learning.

6. Ethical, Legal, and Privacy Implications

Virtual reality (VR) has experienced widespread adoption in K–12 and higher education to support simulated learning experiences. Concurrently, there has been a substantial increase in the number of teacher preparation programs that incorporate virtual reality (VR). In particular, several studies have begun to explore the potential of VR to serve as a professional development tool for prospective classroom educators. Yet, little systematic attention has focused on how VR may support the unique, multifaceted preparation needs of teachers entering positions in high-demand areas, such as mathematics and science, or those that serve a particular population (Evangelia Stavroulia & Lanitis, 2019).

7. Future Directions and Research Gaps

Despite growing interest in VR as a novel instructional media, further research is needed on its potential role in teacher education, especially regarding underexplored pedagogical topics and the design of new VR implementations within pre-existing frameworks. Open questions encompass the long-term consequences of VR as a teacher-training tool, effective practices for promoting pedagogical content knowledge through VR technologies, and the impact of different VR designs on teacher preparation. Such inquiries can be investigated through the examination of pre-service teachers' reflections and lesson-planning documents, qualitative semi-structured interviews, computational tools for tracking teacher-formation trajectories, and pedagogical content-knowledge assessments, thereby enhancing the understanding of VR-driven teacher-education processes and refining emerging scenarios. Prospective studies may also address the sustainability of VR resources and their incorporation into hybrid models informed by education and digital-technology research (Evangelia Stavroulia & Lanitis, 2019).

Moreover, systematic reviews of teacher-education research in both VR settings and more traditional environments may help identify promising topics for further exploration (Ke et al.,

2021). Given that affordable stand-alone VR headsets equipped with advanced capabilities and simplified development applications are now widely available, attempts to scale teacher-preparation programs are a promising avenue for investigation. By distributing teaching simulations over multiple locations, the development of low-cost VR environments aligns with current initiatives to enhance—rather than replace—face-to-face instruction. Online training, peer observation, and cooperative lesson planning represent collaborative actions that readily lend themselves to virtual enactment; fundamental infrastructural requirements and personnel education need to be clarified.

8. Conclusion

Teacher preparation programs emphasize the importance of developing pedagogical skills to facilitate student learning. Virtual reality (VR) technology offers a valuable tool for teachers to hone their classroom management and instructional strategies without jeopardizing real students' learning experiences. Simulated classroom environments provide opportunities for teacher candidates to rehearse essential skills, embrace reflective practices, and receive immediate feedback on their own teaching performance. Evidence indicates that VR-based instruction is effective in improving teacher candidates' perceptions of preparedness and confidence, while related skill acquisition translates into real-world practice.

Based on an extensive review of the literature, this synthesis outlines the theoretical underpinnings and practical applications of VR in teacher education programs, as well as existing empirical research on associated learning outcomes. Considerations for implementation, including hardware and software requirements, ethical and privacy concerns, and obstacles to adoption, are also addressed. The findings underscore VR's vast potential as a pedagogical tool and offer concrete guidance to enhance the effectiveness of teacher preparation programs.

VR plays a transformative role in the field of education by creating immersive simulations of real-world experiences. Immersive simulations transport learners into rich, interactive environments that replicate the physical world, thereby facilitating authentic experience and action while preserving safety and reducing cost. Applied within teacher education, VR simulates classroom contexts in which pedagogical skills can be practiced. Teacher candidates engage in peer-to-peer instruction and receive targeted feedback on critical practices, including lesson design, student engagement, instructional quality, and classroom management (Ke et al., 2021). Additionally, VR supports the development of culturally responsive and inclusive pedagogy by enabling educators to explore diverse scenarios while remaining situated in their own environments (Evangelia Stavroulia & Lanitis, 2019).

Overall, VR enables rehearsal of skills within active, authentic learning contexts and fosters social interaction through peer observation, modeling, and feedback. Such intensive practice is crucial when developing complex, fragile competencies that are seldom acquired through traditional approaches.

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