



Feasibility of Educational Metaverse for Immersive Transformation of Teacher Education

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ABSTRACT

The rapid advancement of immersive technologies has catalyzed transformative shifts across various sectors, particularly in education, where the potential for immersive learning environments holds considerable promise. However, empirical studies focusing on the implementation of immersive technologies within developing countries like Pakistan remain limited, presenting a critical gap in the literature. This study investigates the integration of the educational metaverse into teacher education in Pakistan, emphasizing infrastructural readiness, stakeholder roles, and ethical considerations. Despite the transformative potential of immersive technologies in enhancing pedagogical processes, significant challenges persist related to technological infrastructure, stakeholder engagement, and policy frameworks. Through qualitative analysis of interviews with key educational stakeholders, the research identifies critical barriers and opportunities within the Pakistani context. The findings of this study advocate a strategic, phased method to financing and establishing a robust support systems vital for the effective adoption of educational metaverse in teacher education. This study provides a practical and theoretical understanding of implementation of immersive technologies, hence presenting a framework for universities and policymakers of teacher education focusing to harness immersive innovations effectively.



Introduction

The emergence of digital technologies has evidently influenced education being markedly a major beneficiary of this digital revolution. The incorporation of digital tools and technologies has revolutionized traditional educational practices over past decade, fostering more interactive and dynamic learning environments (Andrin et al., 2024; Nurdiana et al., 2023; Okoye et al., 2023; Timotheou et al., 2023). This transformation is embedded in global movement towards digitization of education, which not only focuses on expanding the access to education but enhance the effectiveness and quality of learning experiences as well (Alenezi, 2023).

The emergence of concept of the educational metaverse, within this extensive continuum of educational technologies, characterizes a transformative shift. The metaverse which is a virtual shared space emerged by conjunction of virtually-enhanced physical as well as digital reality, presents an immersive learning environment that may simulate the real world scenarios in unique ways (Khalil, Haqdad & Sultana, 2023; Ritterbusch & Teichmann, 2023). In the context of teacher education, as claimed by Fitria (2023), the implications of metaverse technology are insightful as it offers an arena where the prospective teachers can be involved in near-realistic classroom practices, encounter with AI-driven avatars of students, and do experimentation with the pedagogical approaches in a virtual setting (Wang & Li, 2024). The potential of

educational metaverse for bridging gaps between theory and practice might ominously enhance the digital readiness level and training of prospective teachers by equipping them with necessary competencies to succeed in progressively digital and interactive educational landscapes.

The adoption and integration educational metaverse in teacher education, specifically in developing countries like Pakistan, face inimitable challenges along with opportunities. In spite of a mounting pursuit to leverage immersive technologies for educational enrichment, Pakistani universities often wrestle with challenges regarding funding, infrastructure, and readiness for integrating these advanced technologies (Kang & Haider, 2024; Qazi, Sharif, & Akhlaq, 2024; Bećirović & Dervić, 2023). The gap between potential of educational metaverse to bring immersive transformation in teacher education, and current technological readiness levels of institutions identifies a critical area of study. By analyzing the feasibility for implementation of these immersive technologies in the context of Pakistan is necessary for not only understanding technological and infrastructural requisites, but also shifts in curriculum and pedagogical practices essential for maximizing the benefits of educational metaverse (Adeniyi et al., 2024; Kuteesa, Akpuokwe, & Udeh, 2024; Asfahani, El-Farra, & Iqbal, 2023; Chugh, Turnbull, Cowling, Vanderburg, & Vanderburg, 2023). This analysis will contribute to a broader understanding of how emerging technologies can be harnessed to foster significant educational transformations, setting the stage for a detailed exploration of the elements that could facilitate or hinder the successful integration of the educational metaverse in teacher education systems.

Building on the established context that the educational metaverse represents a significant evolution in educational technologies, there emerges a distinctive research gap particularly evident in the Pakistani educational context. Despite the global discourse on the transformative potential of immersive technologies like the educational metaverse, empirical studies specifically addressing their implementation within developing countries remain limited (Al Khateeb & Alotaibi, 2024; Khadka, 2024; Al-Sharafi, Al-Emran, Al-Qaysi, Iranmanesh, & Ibrahim, 2023; De-Felice, Petrillo, Iovine, Salzano, & Baffo, 2023). Most research has centered on accessible technologies such as e-learning platforms, often overlooking the complexities involved in deploying more immersive, infrastructure-intensive systems in regions facing economic and technological constraints. Moreover, while much of the existing literature focuses on the technical aspects and user interface design, there is a marked deficiency in studies that delve into how these technologies can be integrated into the curriculum specifically for teacher education (Kayyali, 2024; Bizami, Tasir, & Kew, 2023; Fernandes, Rodrigues, Teixeira, & Werner, 2023; Turan & Karabey, 2023). This gap highlights a significant oversight, as the potential for the educational metaverse to enhance the pedagogical skills and readiness of future teachers remains underexplored. Without targeted research into these areas, the opportunity to leverage these technologies to their fullest potential in preparing educators who are adept at using innovative tools in their teaching practices is missed. This deficiency not only hampers the theoretical understanding but also limits practical advancements in using immersive technologies to elevate the quality of teacher education in Pakistan

In response to the identified gaps, this research aims to meticulously analyze the feasibility of integrating the educational metaverse for immersive transformation in teacher education within Pakistan. The objective centers on evaluating how these advanced digital technologies can be harnessed to enhance teacher training programs, focusing on the pedagogical integration, infrastructure requirements, and potential barriers to implementation (Buragohain, Deng, Sharma, & Chaudhary, 2024; Serrano-Ausejo & Mårell-Olsson, 2024; Chng, Tan, & Tan, 2023; Dengel, Buchner, Mulders, & Pirker, 2021; Bower, DeWitt, & Lai, 2020). By doing so, the study seeks to bridge the gap between the theoretical potential of immersive educational technologies and their practical application in a context that has historically been underrepresented in this field of research. This analysis is crucial as it promises to provide actionable insights that could guide educational policymakers and institutions in developing strategies that not only foster technological adoption but also enhance the quality and effectiveness of teacher education through innovative, immersive learning environments.

Research Questions

This research study aims to analyze the feasibility of educational metaverse for bringing immersive transformation in teacher education. To proceed with this objective, the study explores three research questions:

- 1- What is the readiness level of teacher education departments/institutes to support the implementation of the educational metaverse in terms of technological infrastructure, resources, and past experiences with adopting new technologies?

- 2- What roles should stakeholders of teacher education play in successful adoption and integration of the educational metaverse, and what types of support and partnerships are essential for this process?
- 3- What is the perceived impact of the educational metaverse on teaching practices within teacher education, and what ethical considerations and policy changes are necessary to facilitate its adoption?

Literature Review

The integration of digital technologies into the educational sector marks a significant shift towards more interactive and engaging learning environments. At the forefront of this evolution is the educational metaverse, which leverages immersive technologies to transform traditional educational practices. These advancements offer promising new approaches to education, particularly in the realm of teacher training, where they facilitate the application of theoretical knowledge through dynamic and virtual experiences. Globally, these technologies are reshaping how educators approach teaching and learning, introducing possibilities that extend beyond the physical classroom and into virtual spaces that mimic real-world complexities.

By integrating immersive technologies like AR (Augmented Reality) and VR (Virtual Reality), education sector is following a significant transformation. These immersive technologies which are pivotal to educational metaverse development offer potential to transform teacher education by enriching experiential and interactive learning opportunities. This review meticulously explores the potential adoption of educational metaverse, assesses its applicability and feasibility in teacher education within universities of Pakistan, and deliberates the potential influences on curriculum, pedagogical approaches and the policy implications.

Integration of Immersive Technologies in Education

Immersive technologies ominously enhance learning outcomes while offering dynamic and interactive learning environments. Research studies have demonstrated that VR and AR enhance learning by simulating complex, real-world environments, allowing for deep immersion and better conceptual understanding in teacher training programs (Familoni & Onyebuchi, 2024; Wahyunto, Heriyanto & Hastuti, 2024; Lin & Yu, 2023). The adaptability and flexibility of immersive technologies makes their integration possible into diverse educational settings, addressing various educational contexts and needs. Research studies regarding regions with limited resources (Animashaun, Familoni & Onyebuchi, 2024; Rashid & Alcorin; 2024; Sakpere, Ezika, & Isafiade, 2023) illustrate the ways these immersive technologies have been acclimated and customized to overcome the constraints concerning infrastructure and resources, establishing their effectiveness amid diverse socio-economic backgrounds. Immersive technologies make education more inclusive by catering differentiated learning styles, as suggested by empirical data about using immersive technologies in education for facilitating multiple learning styles, thereby promoting inclusivity and adjusting diverse learners needs (Aguayo & Eames, 2023; AlGerafi, Zhou, Oubibi, & Wijaya, 2023; Kuhail, ElSary, Farooq, & Alghamdi, 2022; Dick, 2021; Pellas, Mystakidis, & Kazanidis, 2021). Hence the immersive technologies are revolutionizing educational practices globally by establishing adaptability within different socio-economic contexts, enhancing learning outcomes, and catering diverse learning styles, thus causing education more effective and inclusive.

Technological Adoption in Pakistan

Financial and structural constraints substantially hinder the adoption of innovative technologies in education sector of Pakistan. Many researchers in their studies have addressed the issues of inadequate digital infrastructure and insufficient funding in various educational institutions of Pakistan as substantial obstacles to adopt the innovative technologies like educational metaverse (Aijaz, Lodhi, Shamim, & Mughal, 2024; Subaveerapandiyan, & Sardar, 2024; Zaidi, Adnan, Lewis & Fatima, 2024; Khalil, A., Saher, U., & Haqdad, 2023). Furthermore, other factors such as digital literacy lacking among educators and cultural resistance slow down the integration and adoption of innovative technologies in education. Evidences show that Pakistani educators resist to adopt innovative technologies, often based on lack of awareness (Ahmad, Batool, & Bhatti, 2024; Alvi, 2023; Mughis, 2023) and adequate training (Ghani, Malik, & Ullah, 2024; Phulpoto, Oad, & Imran, 2024; Alqahtani & AlNajdi, 2023; Badshah et al., 2023) which restrict the effective utilization of immersive technologies. In spite of challenges, there is a significant identification of potential benefits caused by immersive technologies to enhance educational outcomes. Thought leaders and educational policymakers in Pakistan imply an increasing familiarity and interest to leverage immersive technologies for revitalizing student engagement and teacher education overall (Hamzah, Abdullah, & Ma, 2024; Murala, 2024). Since, in education, adoption of immersive technologies is defied by cultural and infrastructural barriers, however an increasing awareness among educational leaders and policymakers

implies an enhanced readiness for embracing these transformative technologies for enhancement in teacher education.

Theoretical Foundations Supporting Technology Adoption

The effective integration of innovative technologies in education systems can be envisaged and well understood with the help of established theoretical frameworks that explicate the main factors effecting technology adoption, acceptance and implementation. The DoI (Diffusion of Innovations) theory insinuates the dynamics of different factors prompting the adoption of innovative technologies in education. The DoI theory implies that ‘perceived benefits’, ‘compatibility with prevailing values’, and ‘simplicity of use’ are crucial for the integration and acceptance of innovative modern technologies in educational contexts (Ayanwale & Ndlovu, 2024; Gökçearsan, Yildiz Durak, & Atman Uslu, 2024; Al Breiki, Al Abri, Al Moosawi, & Alburaiki, 2023; Granić, 2022; Pinho, Franco, & Mendes, 2021).

Moreover, TAM (Technology Acceptance Model) offers a framework to support acceptance of innovative technologies on the basis of ‘ease of use’ and ‘perceived usefulness’. Research studies employing TAM in educational contexts in developing countries (Kusmawan, 2024; Adarkwah et al., 2024; Asad et al., 2023; Asghar, Barberà, & Younas, 2021) have highlighted these factors critically influencing teachers’ willingness for adopting and effectively using novel technologies. Besides, Socio-cultural factors notably effect the adoption of innovative technologies in education. Cultural customs and standards, and prevailing educational practices substantially play a vital role to influence the effectiveness and adoption of innovative educational technologies (Nazir & Khan, 2024; Khalil, Haqdad, & Sultana, 2023; Wu & Yu, 2023; Kamal, Shafiq, & Kakria, 2020). These theoretical frameworks explain the diverse factors affecting technologies adoption but uncover a crucial need for further context-specific research studies to effectively influence integration of innovative educational technologies such as educational metaverse.

Despite considerable advancements in the world to apply immersive technologies in education, the researches mostly focus on well-resourced educational environments, having less consideration given to severe constrained contexts. A significant research gap occurs in investigating the ways these immersive technologies may be effectively employed in educational settings with less resources, specifically in the countries like Pakistan, with prevalent challenges of infrastructure and resistance to technological change. Furthermore, though the theoretical frameworks like DoI and TAM are well-established, their implementation in developing regions lacks inclusive contextualization, which are basically different from scenarios where such frameworks are usually applied. A notable deficiency of detailed empirical research is found focusing the long-term effects of immersive technologies like educational metaverse in universities of Pakistan, to integrate these technologies in existing practices and developing supportive policy frameworks.

The educational metaverse has potential to ominously revolutionize teacher education in Pakistan by offering interactive and immersive learning experiences. Though, accomplishing this needs to overcome the cultural, infrastructural, educational challenges. Oke & Arowoia (2022) narrate that a strategic approach including stakeholders’ engagement, policy reforms, and intended initiatives is vital to foster an environment favorable to educational advancements through technological innovations. Moreover, The identified gaps underscore the critical need to proceed with this research, that intends to analyze the rand feasibility of implementing educational metaverse in teacher education in Pakistan. By providing contextual analysis and empirical evidences, this research study focuses on contributing esteemed suggestions for successful integration of immersive technologies in educational settings with less resources, possibly steering policy reforms. This research intends not only fill the existing knowledge gaps but it also provides a roadmap for prospective initiatives focusing the enhancement of teacher education by means of technological innovations.

Research Methodology

A qualitative research methodology is being employed in this research study, as it provides in-depth understanding of complex facts and patterns within specific contexts. Exploratory and descriptive research design is used, associating with constructivist paradigm which focuses on understanding subjective meanings structured by individuals. Ontologically, this research study takes up a relativist stance, identifying multiple realities formed by contextual and social influences. On the other hand, epistemologically, this study adopts an interpretivist approach which implies that knowledge is co-constructed by means of interactions between participants of study and the researcher. The sample of study consists of deans/heads of teacher education departments from two public and two private universities in Pakistan. The sample is selected through purposive sampling technique to ensure rich and diverse perspectives. This research methodology is suitable for this research study as it permits a distinctive exploration of feasibility for integrating educational metaverse particularly in teacher education, annexing contextual factors and complexities that might be overlooked by quantitative methods. Thematic analysis is followed to systematically analyze the interview data.

Findings of The Study

Technological Readiness for the Educational Metaverse

The interview data analysis divulges mixed readiness level in universities of Pakistan to integrate educational metaverse in teacher education. Whereas foundational presence of robust IT infrastructure and primitive educational tools in some institutions, the general preparedness level for supporting advanced digital technologies such as educational metaverse differs significantly.

Current Technological Competences: The technological infrastructure at universities mainly centers around simple digital tools appropriate for traditional online learning. As respondent-1 told, "Our current technological infrastructure is primarily focused on basic educational tools and digital platforms suitable for conventional online learning". Despite this foundational emphasis, some institutions have founded more robust digital systems, as participant-2 highlighted their progress, stating, "Our university has an effective IT infrastructure that has supported many digital initiatives in recent years". At the foreground of technological development, some universities are furnished with technologies, as revealed by Respondent-3, "in our university, we are satisfied for maintaining technological infrastructure which is that is state-of-the-art and well-suited for supporting innovative digital technologies."

Necessary Transformations and Investments: The evolution to cutting-edge immersive technologies like educational metaverse is still out-of-question, requiring significant infrastructural transformations. The digital infrastructure necessary for these immersive technologies is emerging, as one respondent explained, "The infrastructure required to support advanced digital technologies like the educational metaverse is still in its nascent stages". This transition needs to put significant investments in network and hardware. "To fully embrace such immersive technologies, significant investments would be needed in upgrading our hardware and network capabilities," articulated one of the respondents. Besides, the it was underscored by one respondent that an ample all-embracing technological framework is needed for supporting this transition.

Prior Experiences of Innovative Technologies Adoption: Past experiences to adopt novel technologies present a blended landscape of successes and challenges. Inadequate IT support and defiance from faculty to stick on traditional approaches are the challenges mentioned. One respondent uttered "Challenges such as funding constraints, less IT support, and faculty members' resistance to be accustomed to conventional teaching methods sporadically slowed our pace to embrace innovative technologies in past". In spite of these barriers, notable successes are evidenced specially to integrate digital LMS and digital libraries which have substantially enhanced educational accessibility and delivery.

Readiness for Acceptance of Digital Revolution: The readiness to take up digital revolution differs significantly across universities. Some universities are objectively beginning to get engaged with advanced digital technologies, as one respondent portrayed, "We are in initial stages of adopting a digital transformation, with faculty and students turning to be more tech-savvy". Others respondents depicted a moderate readiness level with a progressive engagement and strong technological foundation with digital tools and technologies. Educational leaders in two private universities specified a higher degree of digital preparedness because of proactive investments for integrating cutting-edge technology and innovation culture, as a respondent spoke, "Thanks to our preemptive investments for embracing state-of-the-art technologies and rich culture to assume innovations, our faculty, students, administration and infrastructure are quite ready".

Roles of Stakeholders in Educational Metaverse Integration

The relevant interview data analysis highlights the crucial roles played by various stakeholders to adopt and integrate educational metaverse, over and above the collaborations, partnerships and vital support needed for efficacious implementation.

Partnerships and Support Needed: successful adoption and implementation of educational metaverse in universities necessitates substantial support and robust partnerships. Collaboration with innovative technologies providers is necessary to access advanced digital tools and gain technical expertise, as one respondent highlighted: "Fostering strong partnerships with technologies providers and other institutions having expertise in immersive technologies is critical". Moreover, acquiring financial support from funding agencies and government is crucial to support such technological advancements, as a respondent clarified, "Support and facilitation from governmental, funding agencies and NGOs as financial grants and funding will be essential".

Stakeholders Roles: The effective adoption of educational metaverse is dependent on active participation of many stakeholders. The role of faculty in universities is critical as both developers and adopters as they may profoundly get involved in design, development, implementation and testing phases for ensuring that technology fulfills the educational needs. One respondent in her interview told that "Faculty members can play their roles as adopters of technologies and innovators as well; additionally, they must be

engaged in all phases from design to the testing to tailor these immersive technologies to curriculum prerequisites". Educational administrators are needed to facilitate this integration by making available the necessary support and resources, ensuring relevant policies and infrastructure are in place. Policymakers also perform an important role for creating promising conditions through suitable policies and financial support mechanisms.

Policy Changes and Ethical Considerations: while adopting educational metaverse in universities, it may result in suffering lots of ethical considerations which require robust policy changes to support implementation of educational metaverse however making sure that students' information security and data privacy are utmost. It was endorsed by the respondents that the policies should restrict unauthorized access and shield student privacy, *"it must be ensured that the policies safeguard students' privacy by restricting illicit access and securing data"* stated one respondent. One more key concern is impartial and equitable access to technologies which involves the efforts required for providing all students with access to these innovative technologies irrespective of their socio-economic eminence. The same was discussed by one respondent that *"equitable access to technologies is crucial and we must attempt to provide uniform access of innovative technologies to all students"*. Moreover, it is also crucial to establish guidelines to ethically use these technologies for enhancing educational outcomes.

Preparation for Educational Metaverse Integration: It needs to encompass many strategic efforts to get prepared for integrating educational metaverse encompasses many strategic steps. Improving the IT infrastructure to better support the adoption of immersive technologies comes first. The same was emphasized by one of the respondents, *"to support educational metaverse by enhancing technological infrastructure at our university involves upgrading the network capabilities and getting suitable hardware"*. Furthermore, across-the-board faculty training is also crucial for ensuring effective utilization and sustainability of these technologies, as one respondent highlighted that *"it is essential to invest for conducting comprehensive trainings for faculty to ensure effective incorporation of metaverse technologies in their pedagogical practices"*.

Potential Impact of the Educational Metaverse

Impact on Pedagogical Practices: Highly engaging and interactive learning environments are developed through immersive technologies like educational metaverse, that simulate real-life scenarios, radically enhancing the curriculum. As one of the respondents articulated, *"the immersive technologies let us simulate the real-life teaching contexts, enhancing the curriculum and getting teachers prepared for contemporary classrooms"*. The educational metaverse supports real-world application of theoretical knowledge by presenting platforms where prospective teachers can safely enhance their teaching approaches, therefore bridging theory and practice gap.

Strategic Planning and Investment Prioritization: This is strategic priority of universities to invest in technological innovations. Some universities are deliberating the phased investments for initiating pilot projects to examine the scalability and educational benefits such latest technologies. In line with this, one of the respondents mentioned that *"To invest in emerging technologies such as educational metaverse is critical for enhancing and sustaining our educational standards, whereas meticulous planning and precise assessment before pervasive implementation of educational metaverse is much needed"*.

Long-Term Vision and Sustainability Concerns: Emerging immersive technologies are anticipated to turn out to be pivotal in teacher education by offering immersive and personalized learning experiences. One respondent shared that *"over next decade, the emerging technologies like metaverse will profoundly change the ways of teaching and learning as the evolving role of digital and immersive technologies is exceeding day-by-day. Though, sustainability and maintenance concerns like 'effects of elevated digital consumption on environment', 'continuous technological updates', and 'continuous professional development' for teachers are crucial matters."*

Policy Support: As it is very important to ensure the equitable access and data privacy regarding immersive technologies, respondents expressed the dire need for devising vigorous laws for data protection to safeguard students' information, and making sure that all students are having equal access to immersive technologies. One of the respondents highlighted that *"it is crucial for us to develop guidelines to make sure that these technologies actually enhance educational practices and outcomes without altering fundamental human elements"*. besides, it is essential to establish a favorable policy environment for effective, meaningful and ethical utilization of immersive technologies in education.

Feedback Procedures and Continuous Improvement: For a refined used of educational metaverse, establishing and effective feedback mechanisms is crucial. Systematic feedback from stakeholders assists in regulating and refining these platforms, whereas performance analytics contribute in guiding future updates and understanding stakeholders' engagement. One of the respondents articulated that *"consistent feedback*

from stakeholders helps in adjusting and improving educational metaverse platform". It emphasized the significance of adaptation and continuous monitoring.

Interpretation of Results

The readiness of universities in Pakistan for integrating educational metaverse is manipulated by multifaceted interplay of existing technological capacities, essential investments to upgrade technological infrastructure, previous experiences regarding technology adoption in institutions, and general trends and vision towards embracing digital innovation. The difference in the readiness levels across universities with less and advanced technological capabilities, highlights an unequal degree of potential immersive transformation in education. The respondents clearly indicated that even educational technologies are present at foundational level, a significant shift is needed for adopting immersive technologies such as educational metaverse. This shift includes not only ample financial investments but also a cultural change is required for adopting technological innovations. The experiences shared by the respondents illustrate that the successes caused by emerging technologies regarding educational delivery as well as the challenges to adopt innovative technologies, influence the readiness for adopting educational metaverse. These findings highlight the dire need for specific strategies to enhance digital infrastructure, bring up institutional readiness, and promote a culture which might be receptive to technological innovations for maximizing the potential effectiveness of immersive technologies particularly in the domain of teacher education.

These findings focus the significance of stakeholders' active engagement and a complex support system for effective integration of educational metaverse in universities. The roles of policy makers, administrators, and faculty are pivotal to create a tech-friendly environment. The need for policy support and ethical guidelines features the multi-faceted challenges which should be steered to utilize the maximum potential of immersive technologies to enhance teacher education. The educational metaverse can considerably revolutionize the educational landscape by practicing commitment and strategic planning by effectively addressing allied challenges.

In teacher education, embracing educational metaverse intends to transform pedagogical practices by promoting experiential and highly interactive learning environments. The change concerning these advanced immersive technologies highlight a transformative potential which is aligned with developing educational paradigms, focusing to fulfill the conventional gaps between theoretical and practice effectively. However, there are diverse challenges associated with this transformation, such as policy support, equitable access to technological resources, and ethical considerations. The responses highlight an eager awareness among stakeholders regarding dealing and eradicating these challenges assiduously to ensure that technological innovations actually enhance rather than dominating the human-centric features of teaching. To harness the maximum potential of educational metaverse, the phased implementation strategy and planned prioritization of investments are significant. This inclusive vision highlights a crucial approach for prospective educational practices, signifying that educational metaverse can eminently enrich the pedagogical practices and train teachers to fulfil the requirements of future learning environments.

Discussion and Recommendations

The findings of study highlight the substantial potential of the educational metaverse for transforming teacher education in Pakistan. This is aligned with philosophy of educational metaverse which suggests that immersive environments can ominously enhance pedagogical practices and curriculum by providing realistic and interactive settings, that cause bridging the gaps between theoretical knowledge and practical application (Buragohain, Sharma, & Chaudhary, 2024; Conrad, Kablitz, & Schumann, 2024; Aguayo & Eames, 2023; Bizami, Tasir, & Kew, 2023; Asad, Naz, Churi, & Tahanzadeh, 2021). The findings further support the need for strategic integration of immersive technologies and vigorous support systems for optimizing educational outcomes which is also narrated by Tene et al., (2024) in their research study about integrating immersive technologies in STEM education.

The findings have also revealed the need for planned investments and robust IT infrastructure which aligns with the theory of diffusion of innovations, which focuses on the significance of processes of institutional readiness and adoption for integrating innovative technologies (Chakraborty, U., & Biswal, 2024; Thi Vo, 2024; Alvi, 2023). Similarly, TAM (Technology Acceptance Model (TAM) confirms findings of this study by advocating that 'perceived ease of use' and 'usefulness' put significant influence on the adoption of innovative technologies (Rosli & Saleh, 2024; Al-Adwan et al., 2023; Barrett, Pack, Guo, & Wang, 2023; Fussell & Truong, 2023; Okoro, Nnaji, & Adediran, 2023; Wu & Yu, 2023). These theories assist in contextualizing the considerations and challenges underscored by respondents of this study regarding implementing educational metaverse in teacher education.

Similar opportunities and challenges are being studied in previous researches about adoption of immersive and digital technologies in education, as ones indicated in this research. For example, the research

studies of on the integration of virtual reality and augmented reality in education (Koumpouros, 2024; Tafazoli, 2024; Wang & Li, 2024; Mena, Estrada-Molina, & Pérez-Calvo, 2023) accentuate the need for planning training programs and infrastructure advancements, which are aligned with findings of this study regarding infrastructure readiness and robust support systems as prerequisites. However, present study exclusively contributes to literature while emphasizing on educational metaverse adoption, integration and implementation in the context of teacher education in Pakistan, hence bridging a significant gap of contextualizing immersive technologies in developing countries.

Practically, the findings of this study have substantial implications for policies and practices in education. It is suggested that universities should prioritize financial investments to develop and enhance technological infrastructures and promote partnerships with innovative technologies providers for harnessing maximum potential of educational metaverse. Furthermore, this study emphasizes the significance of equitable access and ethical considerations while suggesting that administrators and policymakers should develop inclusive strategies for addressing identified challenges (Liu, Chen, Tang, Luo, & Guan, 2024; Isa, 2023; Onopriienko, Onopriienko, & Bourekadi, 2023).

Ultimately, as the universities in Pakistan are at lower readiness level to embrace immersive transformation through educational metaverse, the effective and successful adoption as well as integration of educational metaverse in teacher education in Pakistan hinges on investing in infrastructural upgrades, carefully crafted strategies to embrace immersive revolution, robust stakeholder collaborations, and meticulous implementation of ethical parameters, resultantly assuring a transformative uplift in pedagogical practices, curriculum and educational outcomes.

Conclusion

The present study meticulously investigated the feasibility to integrate educational metaverse in teacher education in Pakistan, emphasizing the essential stakeholders' roles, infrastructural readiness, and associated policy and ethical considerations. The findings substantiate that as potential of educational metaverse to bring transformation in teacher education is immense, major challenges are needed to be addressed for completely realizing this potential. The readiness level of universities regarding technological infrastructure notably varies with some universities still in initial stages of adoption of such innovative and novel technologies. The educational metaverse integration required a robust digital infrastructure comprising advanced servers, specific digital equipment, and high-speed wifi connections, which are still lacking in many universities. Phased and strategic financial investments are vital to gradually develop this capacity by reducing financial risks.

Roles of stakeholder are evidently delineated as administrators and faculty in universities are playing momentous roles in adoption and integration of educational metaverse. It is necessary to involve faculty not only in the role of users but as innovators as well who may customize these immersive technologies to the educational needs. Administrators should make sure the indispensable support structures are developed, whereas policymakers are needed to create conducive learning environments through vigorous funding mechanism and supportive policies. Ethical considerations specifically in terms of equitable access, data privacy, and ethical utilization of immersive technologies are paramount. The findings also underscore dire need to devise stringent policies for protection of student information and confirm that students get equal access to innovative technologies. This emphasizes the need of framing ethical guidelines which prevent immersive technologies to dominate fundamental human aspects of learning and teaching.

The findings of this study contribute to the knowledge body by presenting a thorough investigation of factors effecting the educational metaverse adoption in the context of developing countries. It encompasses a theoretical framework of educational metaverse by connecting stakeholders' expectations and practical experiences with theoretical frameworks of DoI (Diffusion of Innovations) theory and TAM (Technology Acceptance Model). This research highlights the transformative potential of educational metaverse in elevating teacher education, but it also underscores the complex relationship of 'technological readiness', 'stakeholder involvement', and 'ethical considerations' which must be steered. For universities in Pakistan to embrace immersive transformation not only includes technological development and enhancement, but it comprises a holistic deal which involves ethical practices, policy support, and comprehensive strategies. Thus, this research holds significant potential to influence educational practices and outcomes in teacher education by equipping teacher educators and prospective teachers with the tools and digital competencies required for the immersive age. The recommendations aim at guiding these universities towards an effective integration, eventually enriching the effectiveness and quality of teacher education through immersive and innovative learning environments.

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