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Perceived Impact and Effectiveness of VR and AR in Higher Education: Evidence from a South African University of Technology

Tlou Merriam Moshi, Motsotua Confidence Hlatshwayo* and Kayode Oyetade
Vaal University of Technology
Vaal, South Africa

Abstract. Virtual Reality (VR) and Augmented Reality (AR) are reshaping higher education by enhancing engagement, knowledge retention, and experiential learning. Nevertheless, most adoption studies reflect global perspectives, focusing little on African contexts. This study fills that gap by offering localized insights into VR/AR adoption at a South African University of Technology, a setting that is mostly absent from existing research. A mixed-methods approach was employed, involving 60 students who completed structured questionnaires with closed- and open-ended items. The quantitative analysis included descriptive statistics, reliability and validity testing, while the qualitative responses were thematically analyzed to discover contextual barriers and enablers. Findings reveal strong confidence: 85% expressed confidence in their ability to learn to operate VR/AR and agreed that its use could improve overall university efficiency. However, high costs, infrastructural deficits, and limited faculty readiness constrain wider adoption. Unlike global trends, socio-economic and institutional realities strongly shape adoption in South Africa. The study contributes uniquely to African higher education literature by contextualising global adoption models within South African realities and proposing practical strategies such as mobile-based AR labs, targeted faculty training, and supportive policy frameworks, for advancing immersive learning in resource-constrained environments.

Keywords: Virtual Reality; Augmented Reality; Technology Adoption; Higher Education; University of Technology

*Corresponding author: Motsotua Confidence Hlatshwayo; *motsotuad@vut.ac.za*

1. Background of the study

Immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) are reshaping Education by creating experiential and interactive learning environments (Wang & Huang, 2025). Globally, these tools have improved engagement, motivation, and retention, especially in complex fields such as science, engineering, and healthcare (Dalgarno & Lee, 2010; Shyr, Wei, & Liang, 2024).

VR allows full immersion in simulated scenarios, supporting experiential learning and safe experimentation in areas like diagnostics or engineering processes. AR, by contrast, enriches physical classrooms by overlaying digital content such as 3D models and simulations onto real-world spaces, making abstract concepts more tangible (Chandrasekera & Yoon, 2018; Wu, Lee, Chang, & Liang, 2013). Collectively, these technologies bridge the gap between theory and practice, promote skill development, and strengthen workplace readiness (Achuthan, Nedungadi, Kolil, Diwakar, & Raman, 2020; Bermejo et al., 2023).

While their innovative potential is well established internationally, adoption in developing regions, including South Africa, remains limited. Persistent infrastructural, financial, and social inequities constrain the integration of digital innovations in higher Education (Fitria, 2023; Mpungose, 2020). The Universities of Technology in South Africa are especially affected by this, as they are required to produce graduates in engineering and information technology fit for the 21st century workforce. These educational institutions stand to benefit from immersive learning, but there is limited information on how VR and AR are perceived, used, and maintained in this context.

This knowledge gap restricts the development of strategies for responsible and equitable deployment of immersive technologies in South African higher Education (Khashan, Elsotouhy, Alasker, & Ghonim, 2023). Addressing this gap, the present study investigates the perceptions, benefits, and barriers to VR and AR adoption in a South African University of Technology. Specifically, it explores how students and educators view the usefulness of VR/AR for enhancing learning and identifies contextual enablers and challenges that shape adoption.

By situating the analysis within South Africa's socio-economic realities, the study extends global adoption models such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) to a developing-world context. The findings will provide empirical evidence to inform digital transformation strategies, higher education policy, and institutional practice. In doing so, the study offers practical guidance for leveraging immersive technologies to strengthen graduate employability and contribute to more equitable access to innovative learning tools.

To guide this investigation, the study pursued the following objectives:

- To examine how students and educators at a South African University of Technology perceive the role of VR and AR in enhancing learning outcomes.
- To identify the key enablers and constraints influencing the adoption of VR and AR in a resource-constrained higher education environment.
- To contextualize global adoption models (e.g., TAM, UTAUT) within South African socio-economic realities.

The paper is structured as follows: Section 2 reviews theoretical frameworks underpinning technology adoption and examines global and South African trends in VR/AR integration in higher Education. Section 3 outlines the research methodology, including the mixed-methods design, study context, and data collection procedures. Section 4 presents the findings on stakeholder perceptions, benefits, challenges, and adoption trends. It also discusses the implications for policymakers, educators, and institutional leaders, offering practical recommendations and future research directions. Section 5 discusses the study limitations and Section 6 concludes the paper by summarizing key insights and reflecting on the innovative potential of VR/AR in advancing equitable and practical education.

2. Literature review

This section reviews theoretical models and empirical studies on VR and AR adoption in higher Education. It draws on established frameworks such as the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), Innovation Diffusion Theory (IDT), and the Task Technology Fit Theory (TTF) to analyse user acceptance of technologies. It explores global and South African implementation trends, educational applications, barriers, and research gaps.

2.1 Theoretical and Conceptual Foundations for Technology Adoption

Understanding the adoption of VR and AR in higher Education requires grounding in well-established technology adoption models. This study draws on four key theoretical frameworks: TAM, UTAUT, IDT, and TTF. Each model offers distinct perspectives on user acceptance, providing a multidimensional lens through which to explore the adoption of VR/AR in South African Universities of Technology.

2.1.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) posits that perceived usefulness (PU) and perceived ease of use (PEU) are key determinants of technology adoption, shaping behavioural intentions and actual usage(Oyetade, Zuva, & Harmse, 2020). In higher education, TAM has been widely applied to understand adoption of immersive tools like VR and AR. Studies show that practical utility often outweighs attitude in driving adoption. For instance, Shyr et al. (2024)) found that PU and PEU independently influenced students' intentions to adopt VR/AR in an automation course, while Chen, Liu, Chiu, Lee, and Wu (2023) emphasized the role of PEU in mobile VR/AR for smart libraries. Similarly, Al-Adwan et al. (2023)

highlighted personal innovativeness, self-efficacy, and enjoyment in metaverse adoption. Collectively, these findings present the need for VR/AR tools to be user-friendly and demonstrably beneficial, especially in resource-constrained contexts.

2.1.2 Unified Theory of Acceptance and Use of Technology (UTAUT)
The UTAUT model extends TAM by incorporating performance expectancy, effort expectancy, social influence, and facilitating conditions, providing a holistic view of how contextual and interpersonal factors shape technology acceptance (Oyetade et al., 2020; Venkatesh, Morris, Davis, & Davis, 2003). Applied to VR/AR, Noble et al. (2022) found that performance expectancy, perceived learning benefits, was the strongest determinant of adoption, highlighting the importance of alignment with educational outcomes.

Khashan et al. (2023), using a hybrid UTAUT2 and Technology Fit Theory model, emphasized perceived risk, motivation, and facilitating conditions in low-income contexts. Alroqi (2021) added resistance to change to UTAUT2 but found it less influential than enabling conditions, such as institutional support and professional development. Additionally, Du and Liang (2024) noted that cultural and psychological factors and a favourable institutional climate are critical for sustained VR/AR integration.

2.1.3 Innovation Diffusion Theory (IDT)
Rogers' Innovation Diffusion Theory (IDT) emphasizes innovation attributes such as relative advantage, compatibility, complexity, trialability, and observability as key drivers of adoption (Alturki & Aldraiweesh, 2022). This framework is particularly relevant for understanding VR/AR uptake in educational settings. Alsomali (2023) found that academic staff's self-efficacy, perceived fatigue, and resistance to innovation influenced adoption decisions. Achuthan et al. (2020) highlighted trialability and compatibility as critical for implementing virtual laboratories in engineering education, especially in developing countries. These findings underscore the importance of experiential access and contextual alignment for technology adoption, a key consideration for South African institutions facing infrastructure and skills limitations.

2.1.4 Task Technology Fit Theory
Task–Technology Fit (TTF) theory argues that technology delivers the greatest benefits when its capabilities align with the tasks it supports, a framework increasingly used to evaluate VR and AR in higher education. VR/AR affordances like immersion, interactivity, and spatial visualization, fit well with tasks requiring experiential practice, spatial reasoning, and safe simulation of real-world scenarios (Daniela, 2020; Scavarelli, Arya, & Teather, 2021). Empirical studies show that when students and instructors perceive strong task–technology alignment, engagement, learning effectiveness, and performance improve (Al-Rahmi et al., 2023; Maričić et al., 2025). Thus, the effectiveness of VR/AR in higher education depends less on novelty and more on aligning technological features with pedagogical goals and learner needs.

2.1.5 Conceptual Framework for VR/AR in Higher Education

Building on these theoretical foundations, this study develops a unified conceptual framework that integrates key constructs from TAM, UTAUT, IDT, and TTF into a single model tailored for VR/AR adoption in South African Universities of Technology as conceptualized by Scornavacca (2010). Rather than treating these theories as separate lenses, the framework synthesizes their most relevant factors:

- Technology Fit: The degree to which VR/AR technologies align with academic tasks and vocational learning objectives.
- Perceived Usefulness and Ease of Use: Users' beliefs about the efficacy and effort required to use these tools.
- Use: The actual frequency and nature of VR/AR engagement.
- Impact: Individual-level outcomes (e.g., improved learning, motivation) and organizational outcomes (e.g., institutional efficiency, graduate employability).

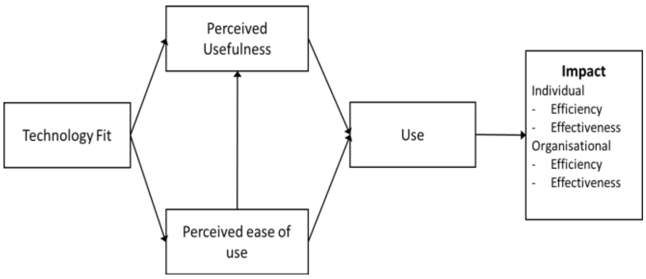

Figure 1: Technology Acceptance Model (Scornavacca, 2010)

The framework is contextualized to South Africa's higher education environment, addressing structural challenges like limited broadband access, uneven digital literacy, and constrained institutional budgets. Policy priorities around widening access and improving employability influence VR/AR adoption, while cultural factors such as scepticism about technology's educational value and varying faculty confidence also shape adoption intentions (Fitria, 2023; Gudyanga, 2024). This context-responsive framework offers a holistic view of immersive technology adoption in resource-constrained universities, investigating the perceived impact of VR and AR technologies in South African Universities of Technology.

2.2 Global and Local Perspectives on VR/AR in Higher Education

This section investigates international VR/AR adoption trends, highlights emerging use cases within South African universities, and explores how these technologies are being used to support immersive and interactive learning experiences, particularly in vocational and technical education contexts.

2.2.1 Global Adoption Trends and Use Cases

Globally, immersive technologies are gaining traction across multiple disciplines. For example, in medicine, VR enables students to conduct surgical simulations while AR enhances real-world learning by overlaying digital content on historical artifacts or biological specimens (Bermejo et al., 2023; Wu et al., 2013). These tools promote active learning, conceptual understanding, and collaboration, especially in STEM and arts education (Lindgren & Johnson-Glenberg, 2013). Furthermore, VR/AR applications are increasingly used in distance education to provide consistent, engaging learning experiences, regardless of location or physical infrastructure.

2.2.2 Emerging Use in South African Universities

In South Africa, the adoption of VR and AR is at an early stage, though growing interest is evident. Pioneering institutions like Stellenbosch University have introduced virtual laboratories to address gaps in practical training (Fitria, 2023). Universities of Technology are well-positioned to benefit from these tools, which can simulate industrial processes and augment engineering education. However, implementation remains uneven and limited primarily to pilot projects. Financial constraints, infrastructural deficits, and digital inequities continue to hamper broader deployment (Akinradewo et al., 2025). Despite these limitations, VR/AR technologies offer considerable promise for improving access to quality education, especially in underserved rural areas (Gudyanga, 2024).

2.2.3 Immersive Learning Applications and Pedagogical Value

Integrating VR/AR into higher Education has increased learner engagement, comprehension, and retention. VR facilitates safe, simulated environments for hands-on learning, such as prototype testing and virtual field trips. AR enhances interaction with physical content by projecting digital annotations or simulations, enriching real-time understanding (AlGerafi, Zhou, Oubibi, & Wijaya, 2023). These technologies are especially valuable for visualizing abstract concepts and conducting high-risk practical tasks without physical danger. However, successful integration requires investments in infrastructure, faculty training, curriculum alignment, and inclusive design (Akinradewo et al., 2025).

2.3 Barriers and Challenges of VR/AR Adoption

Despite their promise, VR/AR technologies face several adoption barriers. Among them are high hardware, software, and internet connectivity costs, particularly in resource-constrained institutions (Köroğlu, 2025). Other critical challenges include a lack of digital literacy, inadequate institutional support, and pedagogical resistance (Alroqi, 2021). These challenges are made worse in South Africa by historical inequalities, with rural universities facing disproportionate barriers when it comes to implementing and using innovative teaching technology (Alsomali, 2023; Khashan et al., 2023). Overcoming these barriers requires systemic reforms, capacity building, and sustained investment in infrastructure and training.

2.4 Research Gap

While international research has explored VR and AR in higher Education, particularly in STEM and healthcare, empirical studies on South African universities of technology remain scarce. These institutions focus on vocational and industrial training but face significant infrastructural and socio-economic constraints (Khashan et al., 2023). Global technology adoption models often overlook these contextual challenges, limiting their applicability. This study addresses this gap by examining stakeholder perceptions, barriers, and enablers of VR/AR adoption, generating context-specific evidence to inform localized integration strategies and support policy and practice in South African higher Education.

3. Research Methodology

3.1 Research Design

A convergent parallel mixed-methods design was employed where quantitative and qualitative data were gathered concurrently, analysed independently, and then merged during interpretation. This design enabled breadth and depth: the survey quantified adoption constructs (e.g., Perceived Usefulness, Perceived Ease of Use, Technology Fit), while qualitative responses contextualised these patterns within institutional realities. Integration used a side-by-side comparison technique, evaluating statistical data alongside qualitative themes.

Convergences reinforced findings, while divergences highlighted contextual details unique to South Africa. Even though the quantitative strand was given more weight to test adoption constructs, qualitative data were essential to explaining "why" and "how" adoption barriers and enablers function in real-world situations. This emphasis is consistent with the study's aim of adapting global adoption models (TAM, UTAUT) to local socio-economic realities.

3.2 Study Setting and Population

Purposively chosen for its vocational emphasis and industry relevance, the research was conducted out at a South African University of Technology. These institutions prepare graduates in applied fields such as engineering, Information Technology (IT), and applied sciences making them ideal for studying immersive technology adoption. The study population included students and academic staff engaged in teaching, learning, or supporting digital technologies. Purposive sampling ensured inclusion of participants from disciplines where VR/AR is most applicable (engineering, IT, and applied sciences).

To obtain deeper perspectives for the qualitative strand, a subset of respondents who provided rich open-ended responses was investigated. Although the sample size (n = 60) limits statistical generalisability, the mixed composition of stakeholders enhanced internal validity and provided a holistic view of adoption dynamics in a resource-constrained context.

3.3 Data Collection Methods

Data were collected using a self-administered questionnaire comprising closed- and open-ended items, ensuring coherence across data types while minimising fatigue.

Quantitative component: Closed-ended items measured Perceived Usefulness (PU), Perceived Ease of Use (PEU), Technology Fit (TF), Intention to Use (IU), and perceived impacts at individual and organisational levels. Responses were recorded on a 5-point Likert scale, where 1 represented strongly disagree and 5 represented strongly agree. The items were modified from validated TAM and UTAUT scales. This made it possible to assess for validity and reliability as well as statistically analyse the correlations between constructs.

Qualitative component: Open-ended questions invited reflections on experiences, anticipated benefits, and perceived barriers. These insights contextualised the quantitative findings by highlighting institutional dynamics such as faculty readiness, infrastructural constraints, and cultural factors. The dual-format design balanced standardisation with flexibility, providing measurable evidence of adoption patterns while capturing the lived experiences shaping VR/AR integration in the case-study institution.

3.4 Data Analysis Techniques

3.4.1 Quantitative Analysis

To guarantee data integrity, the Shapiro-Wilk test and histogram inspections were used to evaluate normality, listwise deletion was used to address missing values, and standardized z-scores (±3) were used to look for outliers. Descriptive statistics summarized participants' demographics and perceptions of VR/AR. Likert-scale items were summarized using means and standard deviations. Cronbach's alpha ($\alpha > 0.70$) confirmed that the constructs accurately measured the intended dimensions (Adamson & Prion, 2013). The Cronbach's alpha values for each construct are presented in Table 1.

Table 1: Measurement Scale Cronbach's alpha

Item	Obs	Sign	Item-test correlation	Item-rest correlation	Average interim correlation	Cronbach's alpha
Technology Fit (TF)	60	+	0.9102	0.8666	0.7045	0.9191
Perceived Usefulness (PU)	60	+	0.8904	0.8381	0.7049	0.9227
Perceived Ease of Use (PEU)	60	+	0.7998	0.7120	0.7524	0.9382
Use (U)	60	+	0.9071	0.8621	0.7011	0.9197
Individual Impact (II)	60	+	0.8773	0.8195	0.7118	0.9251
Organisational Impact (OI)	60	+	0.8520	0.7839	0.7250	0.9295
Test scale					0.7140	0.9375

Obs: Observation (number of data or survey responses used to calculate each construct's reliability score)

Sign: statistical significance of each item's contribution to the overall scale.

3.4.2 Qualitative Analysis

Qualitative responses were analysed using thematic analysis. The process involved: familiarization with the data, generating initial codes, clustering codes into themes, and refining them for coherence and distinctiveness. Themes were defined and illustrated with representative quotations to enhance transparency. Key themes included:

- Alignment with practice-based learning
- Perceived usefulness for student engagement
- Technology fit
- Anticipated learning challenges

For example, one participant noted, "*I think it would make lessons more interactive and help us stay focused,*" highlighting engagement benefits. At the same time, another commented, "*Using VR/AR would make understanding technical procedures* *clearer*," reflecting potential adoption challenges. These findings provide insight into the benefits and contextual barriers to VR/AR adoption.

3.4.3 Mixed-Method Integration
Quantitative and qualitative findings were integrated to understand adoption dynamics comprehensively. In contrast, thematic analysis explained the underlying reasons, particularly contextual barriers such as bandwidth limitations, cost constraints, and faculty training gaps. This triangulation strengthened the validity of findings and produced a multidimensional view of VR/AR adoption at the University of Technology. By integrating statistical analysis with qualitative interpretation, the study produced a detailed, multidimensional understanding of the drivers and inhibitors of VR/AR adoption in the higher education context.

Figure 1 illustrates quantitative trends, interpreted with qualitative themes to show an integrated understanding of adoption dynamics.

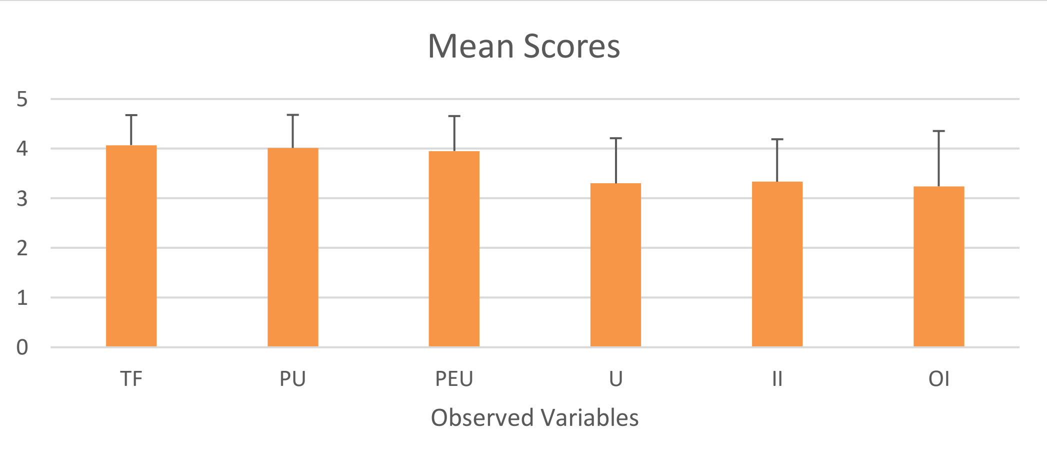

Figure 1: Questionnaire Results

3.5 Ethical Considerations
The study adhered to institutional ethical standards. All participants provided informed consent, and confidentiality was maintained throughout data collection and analysis. Ethical approval was obtained from the university's research ethics committee, ensuring compliance with national and institutional research integrity protocols.

4. Findings & Discussion
This section presents and interprets the findings of the study, structured around key thematic areas: stakeholder perceptions of VR/AR, identified benefits and challenges, usage trends, and comparative analysis with global literature.

4.1 Perceptions of VR and AR in Learning
The findings suggest a generally positive perception of VR and AR integration in Universities of Technology, as presented in Table 2. Many respondents agreed or strongly agreed with all items, indicating acceptance and enthusiasm for these

technologies. For example, 88% of respondents indicated that incorporating VR/AR in their institution is a good idea. Similarly, 85% expressed confidence in their ability to learn how to operate VR/AR and agreed that its use could improve overall university efficiency. These findings demonstrate strong user readiness and a high perceived value of VR/AR for enhancing efficiency and driving innovation within higher education contexts. This immersive learning experience promoted better conceptual understanding and knowledge retention, particularly in technical disciplines such as engineering and information technology.

Table 2: Perceptions of VR/AR in Learning

Construct / Item	Agree/Strongly Agree (%)	Mean (SD)
Learning to operate VR and/or AR would be easy for me.	85%	4.1 (0.8)
I think VR and/or AR would be well-suited in Universities of Technology.	80%	3.9 (0.7)
Using VR and/or AR would enable me to accomplish tasks more quickly.	80%	4.0 (0.9)
I think that using VR and/or AR in Universities of Technology is a good idea.	88%	4.4 (0.6)
The use of VR and/or AR would impact my individual work efficiency.	82%	4.2 (0.7)
Use of VR and/or AR would impact my university's overall efficiency.	85%	4.4 (0.6)

VR was particularly valued for its immersive learning experiences, which motivated students and promoted concentration, conceptual understanding, and knowledge retention in technical disciplines. Students appreciated VR's ability to simulate real-life environments, such as laboratories, workshops, or clinical settings, allowing safe and repeated practice of procedures. AR, in contrast, was praised for its accessibility and practical integration into everyday classroom activities, such as overlaying digital content onto textbooks or physical objects to aid visualization of abstract concepts. These perceptions suggest complementary roles for the technologies: VR for high-fidelity simulations and experiential learning, and AR for continuous, interactive support in physical learning environments.

4.2 Benefits and Challenges Identified

4.2.1 Perceived Benefits

Participants reported several pedagogical benefits of VR and AR. VR promoted experiential learning by allowing students to engage in simulations and virtual field trips that are often impractical in traditional settings. AR enhanced interactivity by overlaying digital information onto physical teaching materials, creating dynamic, multimodal learning environments. Both technologies were seen as bridging the gap between theory and practice. In medicine, science, and engineering, VR enabled safe experimentation and skill development, while AR reinforced understanding by contextualizing theory within real-world frameworks. One student noted, "*VR lets us practice complex experiments safely* *before trying them in the real lab*," another added, "*I can see myself using VR/AR to reinforce lessons, almost like self-study*." These reflections highlight VR's role in immersive simulations and AR's role in supporting day-to-day learning.

4.2.2 Challenges to Adoption:

Despite enthusiasm for VR and AR, several barriers were identified. High acquisition and maintenance costs for VR headsets and AR-compatible devices, particularly in underfunded institutions, were a significant concern. Limited infrastructure, including broadband connectivity, technical support, and device availability, further hindered implementation. Faculty resistance also emerged, often due to limited exposure to VR/AR, lack of structured training, and rigid curricula that leave little room for new pedagogical methods. Some lecturers questioned whether VR/AR genuinely enhances learning or merely offers novelty, and the time required for training and curriculum redesign reinforced this hesitancy. These findings suggest that resistance stems from structural and professional barriers, highlighting the need for technical investment and targeted professional development to support successful adoption.

4.3 Adoption Trends and Usage Patterns

4.3.1 Quantitative Trends

Survey results showed generally positive attitudes toward VR and AR, with students more enthusiastic than faculty. Perceived usefulness strongly predicted intention to adopt these technologies, with a significant positive correlation ($r = 0.65$, $p < 0.01$), aligning with established adoption models. Perceived ease of use scored lower, reflecting limited prior exposure to immersive technologies and suggesting that adoption may be constrained by gaps in digital literacy rather than interest. Foundational training initiatives are therefore essential to build confidence before large-scale implementation. Moreso, lack of resources emerged as a significant barrier, with 60% agreeing it hinders VR/AR adoption, highlighting the financial constraints of South African public universities reliant on government subsidies (Akinradewo et al., 2025).

This highlights the importance of facilitating conditions within the UTAUT framework: without affordable access and institutional support, intention to use may not translate into actual use. Furthermore, students also distinguished between VR and AR. VR was valued for immersive simulations and replicating complex scenarios, whereas AR was seen as more practical for everyday classroom use due to compatibility with personal devices (Fitria, 2023). AR's lower complexity and higher compatibility make it a feasible gateway technology in resource-limited contexts. Educators recognized the potential of immersive technologies but expressed concerns about cost, training, and curriculum fit. These findings highlight a dual reality: optimism about VR/AR's pedagogical potential exists, yet practical barriers must be addressed to move from perception to implementation.

4.4 Comparative Analysis with Global Research

The study's findings align with international research highlighting the benefits of VR and AR for student engagement, visualization of abstract concepts, and experiential learning (Lindgren & Johnson-Glenberg, 2013; Wang & Huang, 2025). The strong influence of perceived usefulness is consistent with Shyr et al. (2024). Unlike Noble, Saville, and Foster (2022), who found that social influence drives adoption, participants in this study emphasized economic and infrastructural constraints as primary barriers. This reflects the contextual realities of South African universities of technology, where chronic funding limitations make investments in dedicated VR labs and advanced headsets unsustainable (Akinradewo et al., 2025; Mugunzva, 2024). Consequently, cost-effective alternatives such as mobile-based AR applications run on students' personal devices are more viable (Fitria, 2023). These findings resonate with Khashan et al. (2023), highlighting the shared challenges of VR/AR implementation in low- and middle-income countries and the need to tailor digital transformation strategies to local conditions.

The study also diverges from global trends in substantive ways. While international research often emphasizes social influence (Noble et al., 2022) and hedonic motivation (Al-Adwan et al., 2023) as adoption drivers, structural barriers such as funding constraints and faculty readiness dominate in South Africa. This implies that adoption models such as TAM and UTAUT need to be modified for situations with limited resources, where institutional support and favourable circumstances are more important than peer pressure.

Universities should invest in IT staff training and use affordable solutions like mobile-based AR laboratories to encourage VR/AR integration. Faculty should embed interactive simulations and AR overlays into curricula, supported by continuous professional development. Policymakers must prioritize digital infrastructure, including broadband expansion, and establish subsidy programs to ensure equitable access. Clear delineation of roles among universities, faculty, and policymakers is essential for translating enthusiasm into sustainable adoption.

These findings also validate the study’s conceptual framework. Lower ease-of-use ratings underscore TAM’s emphasis on digital literacy and usability. High cost and infrastructural barriers reflect UTAUT’s facilitating conditions, while AR’s compatibility with mobile devices illustrates IDT’s focus on complexity and compatibility. Collectively, these patterns demonstrate that, while immersive technologies have promise, their adoption in South Africa is influenced by a complex interaction of human views, institutional capacity, and socioeconomic reality.

5. Study Limitations

Although this study offers insightful information about the adoption of VR and AR at the South African University of Technology, it should be noted that it has several limitations. The small sample size (n = 60) and focus on a single institution limit the generalizability of findings across the higher education sector. Additionally, the cross-sectional design captures perceptions at one point, preventing analysis of how attitudes, adoption behaviours, or learning outcomes evolve.

Future research should address these limitations by including multiple universities, larger samples, and longitudinal designs to examine how constructs such as perceived usefulness, ease of use, and facilitating conditions change and influence sustained adoption. Such studies would deepen understanding of immersive technology diffusion in resource-constrained environments and refine adoption models for higher Education in the Global South.

6. Conclusion

This study examines the potential of VR and AR to enhance teaching and learning in South African Universities of Technology. Students perceive these technologies as effective for fostering engagement, improving knowledge retention, and bridging the gap between theory and practice. Adoption, however, is hindered by high costs, inadequate facilities, and limited training for educators. To explain these dynamics, the study integrates TAM, UTAUT, IDT, and TTF elements into a unified adoption framework.

Perceived usefulness and ease of use (TAM) combine with facilitating conditions and social influence (UTAUT) to highlight the importance of institutional support and peer norms. Innovation attributes like trialability and observability (IDT) explain how exposure and demonstrable benefits reduce uncertainty and build acceptance. This framework captures both individual and institutional determinants of adoption while contextualizing them within South Africa's higher education realities, including digital divides, uneven infrastructure, and faculty confidence.

Key findings indicate that perceived usefulness strongly predicts adoption intentions, students are enthusiastic about immersive tools, and AR is more practical for day-to-day integration than VR; nevertheless, high costs, infrastructural limitations, and faculty resistance temper this optimism. By combining TAM, UTAUT, IDT, and TTF, the study demonstrates that adoption depends on perceived utility and contextual feasibility, offering guidance for universities, faculty, and policymakers. Strategic investments in infrastructure, targeted faculty development, and supportive policy frameworks are essential to leverage immersive learning effectively.

7. Declarations:

Author Contributions

TMM.: Conceptualization and design, literature search, writing – original draft and final draft; MCH: Supervision, writing – original draft and final draft; KO: Writing – review & editing and final draft.
All authors have read and approved the published version of the article.

Conflicts of Interest

The authors declare no conflict of interest.

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Ethical Approval

Ethical approval granted (FACSREC-07022024-142).

Data Availability Statement. The data supporting the findings of this study are available from the author upon request.

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