Int Journal of Social Sciences Management and Entrepreneurship 10(1): 143-155 2026

ISSN 2411-7323

www.sagepublishers.com

ASSESSING TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING THROUGH VIRTUAL REALITY: A FRAMEWORK FOR ITS ADOPTION IN MACHAKOS TOWN SUB-COUNTY, KENYA

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ABSTRACT

Virtual Reality (VR) has emerged as a transformative technology for enhancing practical skills development in Technical and Vocational Education and Training (TVET) through immersive and simulation-based learning environments. Despite its potential to improve learner engagement, safety, and competency acquisition, empirical evidence on the institutional factors influencing VR adoption in Kenyan TVET institutions remains limited, particularly in semi-urban contexts. This study applied the Technology–Organization–Environment (TOE) framework to examine the technological, organizational, and environmental factors influencing institutional intention to adopt VR in TVET institutions in Machakos Town Sub-County, Kenya. Data were collected from trainees and instructors across six TVET institutions using semi-structured questionnaires and analyzed using descriptive statistics, Pearson's correlation, multiple regression analysis, and thematic analysis. The findings revealed that technological, organizational, and environmental factors significantly influence institutional intention to adopt VR, with technological readiness emerging as the strongest determinant. The study concludes that VR adoption in semi-urban TVET institutions is feasible but dependent on adequate technological infrastructure, institutional capacity, and supportive external conditions. A TOE-based assessment and adoption framework comprising technological assessment, organizational implementation, and environmental alignment is proposed to guide institutions from readiness assessment through implementation and long-term sustainability.

Keywords: Virtual Reality (VR); Technical and Vocational Education and Training (TVET); Technology–Organization–Environment (TOE) Framework; Technology Adoption; Institutional Readiness; Educational Technology; Immersive Learning; Kenya.

Background of the Study

The Fourth Industrial Revolution (Industry 4.0) has transformed education systems globally, creating demand for innovative technologies that support practical skills acquisition. Among these technologies, Virtual Reality (VR) has emerged as a transformative tool that enables immersive and interactive learning through simulation of real-world environments. VR allows learners to engage in complex, real-time scenarios that enhance motivation, knowledge retention, and performance, making it particularly suitable for Technical and Vocational Education and Training (TVET), where experiential learning is central to skills development (Makransky & Petersen, 2021). Studies further indicate that VR enhances learners' sense of presence and engagement, thereby improving learning outcomes (Makransky et al., 2021).

Globally, the adoption of VR in TVET has gained momentum, particularly in countries such as Germany, South Korea, and Singapore, where immersive simulations are used in areas including mechanical engineering, electrical installation, and healthcare training (Boel et al., 2024). These technologies provide safe, scalable, and repeatable learning experiences while reducing dependence on expensive equipment and physical training environments. Consequently, learners exposed to VR-supported instruction often demonstrate improved practical confidence and technical problem-solving abilities compared to those trained using traditional approaches (Alshammari et al., 2022).

Despite these advances, VR adoption in Sub-Saharan Africa remains limited due to challenges associated with infrastructure, equipment costs, digital literacy, and policy support (Yusuf et al., 2021). Although pilot initiatives have been reported in countries such as Rwanda and South Africa, large-scale institutional implementation remains uncommon (Alzahrani & Sluss, 2022). Nevertheless, VR continues to be recognized as a promising solution for enhancing technical skills development, particularly in environments where practical training opportunities are constrained.

In Kenya, TVET institutions play a critical role in supporting national development agendas through skills development and workforce preparation. Although the number of accredited TVET institutions increased from 701 in 2012 to 2,396 in 2021 (Republic of Kenya, 2023), the integration of emerging technologies such as VR remains limited. Existing studies identify challenges including inadequate infrastructure, limited instructor capacity, fragmented technology initiatives, and weak institutional support mechanisms that constrain technology adoption in TVET institutions (Kenei & Okumu, 2024; Kipruto & Muthoni, 2023).

Existing literature on VR in education has largely focused on learner engagement, motivation, skill acquisition, and learning outcomes (Makransky & Petersen, 2021; Makransky et al., 2021). While these studies demonstrate the pedagogical value of VR, limited attention has been given to the institutional factors that influence its adoption and sustainability. Similarly, studies conducted within African and Kenyan TVET contexts identify technological and organizational barriers but rarely examine how technological readiness, organizational capacity, and environmental conditions interact to influence adoption decisions (Yusuf et al., 2021; Kenei & Okumu, 2024).

To address this gap, this study applied the Technology–Organization–Environment (TOE) framework to examine the technological, organizational, and environmental factors influencing institutional intention to adopt VR in TVET institutions in Machakos Town Sub-County, Kenya. The study further proposed a TOE-based assessment and adoption framework to guide the sustainable implementation of VR within TVET institutions.

Statement of the Problem

Technical and Vocational Education and Training (TVET) institutions play a critical role in equipping learners with industry-relevant competencies required in increasingly digital and

technology-driven labor markets. Globally, Virtual Reality (VR) has emerged as an effective instructional technology for enhancing learner engagement, knowledge retention, and practical skills development through immersive and interactive simulations (Makransky & Petersen, 2021; Makransky et al., 2021). Despite these benefits, the adoption of VR within Kenyan TVET institutions remains limited.

In Machakos Town Sub-County, evidence indicates low levels of institutional readiness for VR integration. A baseline audit conducted by the Machakos County TVET Directorate revealed that only 9.5% of institutions possessed VR equipment, while none had integrated immersive technologies into curricula, assessments, or instructional practices. Additionally, 92% of instructors reported having no training in VR pedagogy, and more than 70% of institutions lacked essential infrastructure such as stable internet connectivity and functional digital laboratories (Machakos County TVET Directorate, 2023). These limitations are compounded by technical challenges associated with VR implementation, including inadequate hardware, network latency, interoperability constraints, and limited availability of localized VR content (Boel et al., 2024; Ferreira et al., 2024; Lampropoulos et al., 2024).

Although national policy frameworks such as Kenya Vision 2030, the Bottom-Up Economic Transformation Agenda (BETA), and the Presidential Working Party on Education Reform emphasize digital transformation in education, implementation at institutional level remains fragmented. Existing studies have largely focused on the educational benefits of VR or isolated implementation challenges and have not systematically examined how technological readiness, organizational capacity, and environmental conditions influence institutional adoption decisions within Kenyan TVET institutions (Alzahrani & Sluss, 2022; Yusuf et al., 2021).

Consequently, there is limited empirical evidence to guide policy formulation, resource allocation, and strategic planning for sustainable VR adoption in TVET institutions. This study addressed this gap by applying the Technology–Organization–Environment (TOE) framework to examine the technological, organizational, and environmental factors influencing institutional intention to adopt VR in TVET institutions in Machakos Town Sub-County, Kenya.

General Objective

To develop a Technology–Organization–Environment (TOE)-based framework for assessing and guiding the adoption of Virtual Reality (VR) technology in Technical and Vocational Education and Training (TVET) institutions in Machakos Town Sub-County, Kenya. The study was guided by the following specific objectives;

i. To critically review and synthesize existing literature on technology adoption models (TOE), VR in education, and TVET challenges by identifying key features and gaps.
ii. To identify and analyze the key Technological, Organizational, and Environmental (TOE) factors that influence the intention to adopt VR in TVET institutions.
iii. To propose a TOE-based assessment and adoption framework.

Theoretical Framework

This study was guided by the Technology–Organization–Environment (TOE) framework developed by Tornatzky and Fleischer (1990). The TOE framework explains organizational technology adoption through three interrelated contexts: technological, organizational, and environmental. The technological context focuses on the characteristics and readiness of technologies available to an institution; the organizational context examines internal factors such as leadership support, financial resources, staff competencies, and implementation capacity; while the environmental context considers external influences including policy frameworks, stakeholder support, industry partnerships, and regulatory conditions (Tornatzky & Fleischer, 1990; Ofosu-Ampong & Acheampong, 2022).

The framework is particularly relevant to Virtual Reality (VR) adoption in Technical and Vocational Education and Training (TVET) institutions because implementation depends not only on the availability of VR technologies but also on institutional readiness and the broader enabling environment. In this study, the technological context comprised VR-related attributes including superior benefit, complexity, testability, and compatibility, together with infrastructure readiness. The organizational context included leadership commitment, funding availability, staff competencies, and governance structures, while the environmental context encompassed policy support, industry linkages, and external stakeholder support.

The TOE framework has been widely applied in educational technology adoption studies because it provides a holistic perspective that integrates internal institutional factors and external environmental influences (Ofosu-Ampong & Acheampong, 2022; Nautwima, 2025). Although the framework does not explicitly address individual-level factors such as instructor attitudes and learner perceptions, it remains appropriate for this study because the focus was on institutional adoption rather than individual technology acceptance. Consequently, TOE provided a suitable theoretical foundation for examining the factors influencing VR adoption and for developing a contextualized assessment and adoption framework for TVET institutions in Machakos Town Sub-County, Kenya.

Literature Review

Technological Factors and VR Adoption

Technological readiness refers to the extent to which an institution possesses the infrastructure, technical resources, and capabilities required to implement and sustain Virtual Reality (VR) technologies. Within the TOE framework, technological readiness encompasses both infrastructural requirements and innovation attributes such as superior benefit, complexity, testability, and compatibility (Ofosu-Ampong & Acheampong, 2022; Mukred, 2025). Studies indicate that successful VR implementation requires reliable infrastructure, including VR-capable devices, stable internet connectivity, power reliability, and technical support systems (Boel et al., 2024; Lampropoulos et al., 2024). Evidence from vocational education contexts further suggests that institutions are more likely to adopt VR when the technology is perceived as beneficial, compatible with existing instructional systems, and capable of being piloted before large-scale implementation (Makransky & Petersen, 2021; Mukred, 2025). However, limited empirical evidence exists regarding how these technological factors influence institutional adoption decisions within Kenyan TVET institutions.

Organizational Factors and VR Adoption

Organizational factors refer to internal institutional conditions that influence technology adoption and implementation. These include leadership commitment, instructor competencies, governance structures, budgetary support, and ICT support mechanisms (Raji et al., 2023; Chen, 2024). Previous studies have shown that institutions with strong leadership support, structured professional development programs, and dedicated technical support systems are more likely to successfully integrate immersive technologies into teaching and learning processes (Alshammari et al., 2022; Kim & Park, 2021). Conversely, weak governance structures, inadequate staff training, and limited financial resources have been identified as barriers to sustainable implementation (Yusuf et al., 2021). Despite growing interest in immersive technologies, evidence on the influence of organizational readiness on VR adoption within Kenyan TVET institutions remains limited.

Environmental Factors and VR Adoption

Environmental factors comprise the external conditions that influence institutional adoption decisions, including policy support, regulatory frameworks, industry collaboration, donor support, and stakeholder engagement (Satyro et al., 2024). Studies from developed economies

indicate that supportive policy environments and strong partnerships between educational institutions, industry, and technology providers facilitate successful implementation of VR technologies (Boel et al., 2024; Ferreira et al., 2024). In developing countries, however, policy implementation gaps, limited funding mechanisms, and weak stakeholder coordination frequently constrain technology adoption (Sabiteka et al., 2025; Yusuf et al., 2021). Although Kenya has established policy frameworks promoting digital transformation in education, limited empirical evidence exists regarding how environmental conditions influence institutional intention to adopt VR within TVET institutions.

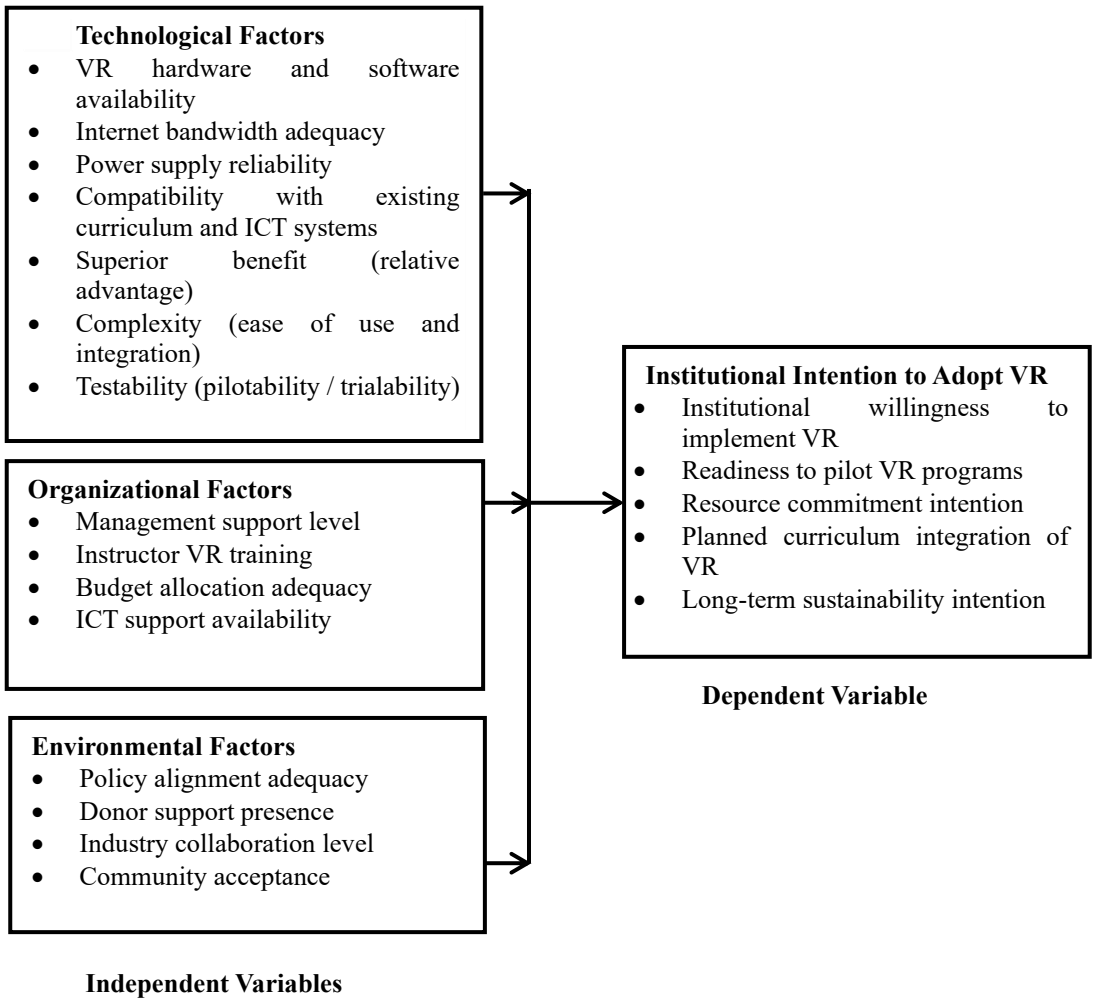
Virtual Reality Adoption in TVET Institutions

Virtual Reality adoption refers to the extent to which immersive technologies are integrated into teaching, learning, assessment, and skills development processes within educational institutions. Existing studies demonstrate that VR can enhance learner engagement, practical skills acquisition, procedural accuracy, and workplace preparedness (Makransky et al., 2021; Santilli et al., 2024). However, adoption remains uneven across institutions due to variations in technological readiness, organizational capacity, and environmental support. While previous studies have examined individual determinants of adoption, limited research has investigated how technological, organizational, and environmental factors collectively influence institutional intention to adopt VR within semi-urban TVET contexts. This study addresses this gap by applying the TOE framework to examine the combined influence of these factors on institutional intention to adopt VR in TVET institutions in Machakos Town Sub-County, Kenya.

Conceptual Framework

This study was guided by the Technology–Organization–Environment (TOE) framework, which posits that organizational adoption of technological innovations is influenced by technological, organizational, and environmental conditions (Tornatzky & Fleischer, 1990). In this study, technological factors comprised VR infrastructural readiness and innovation attributes, including compatibility, superior benefit, complexity, and testability. Organizational factors included management support, instructor training, budget adequacy, and ICT support, while environmental factors encompassed policy support, industry collaboration, donor involvement, and community acceptance.

The dependent variable was institutional intention to adopt Virtual Reality (VR), conceptualized as the willingness and readiness of TVET institutions to initiate, support, and sustain VR integration within teaching and learning processes. The study hypothesized that technological readiness, organizational capacity, and environmental support positively influence institutional intention to adopt VR. The conceptual framework provided the basis for variable operationalization, instrument development, and empirical analysis.



METHODOLOGY

This study adopted a descriptive survey design grounded in the Technology–Organization–Environment (TOE) framework to examine the technological, organizational, and environmental factors influencing institutional intention to adopt Virtual Reality (VR) in Technical and Vocational Education and Training (TVET) institutions. Descriptive survey designs are appropriate for examining relationships among variables within naturally occurring settings and for generating findings that are relevant to policy and practice (Saunders et al., 2023; Creswell & Creswell, 2023). The study was conducted in Machakos Town Sub-County, Kenya, a semi-urban setting comprising six accredited TVET institutions. The target population consisted of 3,500 trainees and 250 instructors drawn from these institutions.

A sample of 359 trainees was determined using Yamane's (1967) formula and selected through proportionate stratified random sampling to ensure representation across institutions. In addition, 30 instructors were purposively selected based on their involvement in technical training and instructional delivery. Proportionate stratified sampling enhances subgroup representation and minimizes sampling error, while purposive sampling enables selection of respondents with relevant expertise and experience (Saunders et al., 2023; Ames et al., 2024).

Data were collected using semi-structured questionnaires administered to trainees and instructors. Semi-structured questionnaires facilitate the collection of standardized quantitative data while allowing respondents to provide contextual insights through open-ended responses (Creswell & Creswell, 2023). The instruments measured technological factors, organizational factors, environmental factors, and institutional intention to adopt VR using five-point Likert scale items and selected open-ended questions.

The instruments were subjected to expert review to establish content validity and were pre-tested in a TVET institution outside the study area. Reliability was assessed using Cronbach's alpha coefficient, with a threshold of $\alpha \geq 0.70$ considered acceptable for internal consistency (Sigüenza et al., 2024). Quantitative data were analyzed using descriptive statistics, Pearson's correlation analysis, and multiple regression analysis in SPSS version 29, while qualitative responses were analyzed thematically to provide contextual explanations for the quantitative findings (Braun & Clarke, 2021).

Ethical approval was obtained from the Kenya Methodist University Institutional Review Board and a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). Participation was voluntary, and informed consent was obtained from all respondents prior to data collection.

RESULTS AND DISCUSSION

The study achieved a response rate of 92.0% (358 respondents), comprising 331 trainees and 27 instructors. Instrument reliability was satisfactory, with Cronbach's alpha coefficients ranging from 0.762 to 0.887, exceeding the recommended threshold of 0.70. These results confirmed the suitability of the data for subsequent analysis.

Descriptive Findings

The study examined the extent to which technological, organizational, and environmental factors influence institutional intention to adopt Virtual Reality (VR) in TVET institutions. The findings revealed moderate levels of readiness across all three dimensions of the TOE framework.

Table 1: Summary of Descriptive Findings

Construct	Mean	Interpretation
Technological Factors	2.95	Moderate
Organizational Factors	2.97	Moderate
Environmental Factors	2.79	Moderate

All three TOE dimensions recorded moderate mean scores, suggesting that institutions possess some readiness for VR adoption but continue to face substantial implementation challenges.

The findings indicate that technological readiness remains constrained by inadequate VR equipment, unstable internet connectivity, limited technical support, and recurring system interruptions. Notably, 70.7% of trainees reported that they had never used VR, while 56.2% identified lack of VR devices as a major challenge and 52.0% cited poor internet connectivity. These findings suggest that although some digital infrastructure exists within the institutions, significant technological barriers continue to limit effective implementation of immersive learning technologies. Similar infrastructural constraints have been reported in Sub-Saharan educational institutions, where inadequate connectivity and equipment shortages hinder technology adoption (UNESCO, 2022; Yusuf et al., 2021).

The results further revealed moderate organizational readiness. While respondents perceived institutional leadership as generally supportive of digital innovation, they reported inadequate instructor training, weak governance structures, limited technical support systems, and minimal integration of VR into curriculum delivery. The findings suggest that organizational support for VR remains largely dependent on individual instructor initiative rather than formal institutional systems. Previous studies similarly found that successful implementation of immersive technologies requires structured training programs, governance frameworks, and coordinated institutional support mechanisms (Alshammari et al., 2022; Raji et al., 2023).

Environmental readiness was also moderate. Respondents acknowledged the existence of national digital transformation initiatives and policy support but expressed concerns regarding

funding availability, regulatory clarity, and the strength of industry partnerships. These findings suggest that although the broader policy environment is generally supportive of digital transformation, institutional implementation is constrained by limited operational support and weak external collaboration mechanisms. This observation is consistent with findings by UNESCO (2022) and Yusuf et al. (2021), who reported that policy-practice gaps frequently constrain technology adoption in African educational contexts.

Collectively, the descriptive findings suggest that VR adoption within the selected TVET institutions is constrained by moderate readiness across all TOE dimensions. Although respondents acknowledged the potential value of VR, technological limitations, organizational capacity gaps, and environmental constraints continue to hinder large-scale implementation. These findings provided the basis for subsequent inferential analysis examining the relationships between TOE factors and institutional intention to adopt VR.

Correlation Analysis

Pearson's Product-Moment Correlation Coefficient was used to determine the strength and direction of the relationships between the TOE factors and institutional intention to adopt VR.

Table 2: Correlation Matrix

Variable	1	2	3	4
1. Institutional Intention to Adopt VR	1			
2. Technological Factors	.612**	1		
3. Organizational Factors	.543**	.598	1	
4. Environmental Factors	.417**	.486	.503	1

Note: Note: N = 358; **p < 0.05

The results indicate statistically significant positive relationships between all TOE dimensions and institutional intention to adopt VR. Technological factors exhibited the strongest relationship with institutional intention to adopt VR ($r = 0.612$, $p < 0.05$), followed by organizational factors ($r = 0.543$, $p < 0.05$) and environmental factors ($r = 0.417$, $p < 0.05$). These findings suggest that improvements in technological readiness, organizational capacity, and environmental support are associated with stronger institutional willingness and preparedness to implement VR. The results support the Technology–Organization–Environment framework, which posits that organizational technology adoption is influenced by the interaction of technological, organizational, and environmental conditions (Tornatzky & Fleischer, 1990).

Multiple Regression Results

To determine the combined influence of technological, organizational, and environmental factors on institutional intention to adopt Virtual Reality (VR), multiple regression analysis was conducted. The results are presented in Table 3.

Table 3: Multiple Regression Results for the Integrated TOE Model

Variable	B	Std. Error	β (Standardized)	t-value	Sig.
Constant	0.721	0.139	–	5.187	0.000
Technological Factors	0.418	0.043	0.462	9.721	0.000
Organizational Factors	0.301	0.046	0.323	6.543	0.000
Environmental Factors	0.172	0.041	0.191	4.195	0.000

Model Statistics: $R = 0.781$; $R^2 = 0.610$; Adjusted $R^2 = 0.607$; $F = 186.972$; $p < 0.001$

The regression model was statistically significant ($F = 186.972$, $p < 0.001$), indicating that technological, organizational, and environmental factors jointly influence institutional

intention to adopt Virtual Reality in TVET institutions. The model explained 61.0% of the variance in institutional intention to adopt VR ($R^2 = 0.610$), while the adjusted R^2 value of 0.607 confirmed that the model retained substantial explanatory power after accounting for the number of predictors. The explanatory power of the model suggests that the Technology–Organization–Environment (TOE) framework provides a robust basis for understanding institutional VR adoption within semi-urban TVET contexts. These findings support the argument that technology adoption decisions are influenced by multiple interacting institutional factors rather than technological considerations alone (Tornatzky & Fleischer, 1990).

The integrated regression model is expressed as:

$$\text{Institutional Intention to Adopt VR} = 0.721 + 0.418\ \text{Technological Factors} + 0.301\ \text{Organizational Factors} + 0.172\ \text{Environmental Factors}$$

The findings revealed that all three TOE dimensions significantly influence institutional intention to adopt VR. Technological factors emerged as the strongest predictor ($\beta = 0.462$, $p < 0.001$), indicating that infrastructure availability, system reliability, compatibility, testability, and perceived benefits are critical prerequisites for VR implementation. This finding suggests that institutions are more likely to adopt VR when the necessary technological resources and supporting infrastructure are available. The result is consistent with previous studies which found that immersive technology adoption in educational settings depends heavily on technological readiness and infrastructure adequacy (Makransky & Petersen, 2021; Boel et al., 2024).

Organizational factors were the second strongest predictor of institutional intention to adopt VR ($\beta = 0.323$, $p < 0.001$). This finding demonstrates the importance of leadership commitment, staff training, governance structures, technical support systems, and institutional coordination in facilitating successful VR implementation. The result reinforces evidence that organizational capacity determines whether technology initiatives progress beyond acquisition to sustainable implementation and meaningful instructional integration (Alshammari et al., 2022; Raji et al., 2023).

Environmental factors also exerted a positive and statistically significant influence on institutional intention to adopt VR ($\beta = 0.191$, $p < 0.001$), although their effect was comparatively weaker than the technological and organizational dimensions. This suggests that policy support, industry collaboration, funding opportunities, and stakeholder engagement function as important enabling conditions that reinforce adoption efforts. The finding aligns with studies indicating that supportive policy and stakeholder ecosystems are essential for scaling educational technologies, although they are insufficient in the absence of adequate institutional readiness (UNESCO, 2022; Yusuf et al., 2021).

Overall, the findings demonstrate that VR adoption in TVET institutions is shaped by an interdependent system of technological readiness, organizational capacity, and environmental support. Technological readiness provides the foundation for adoption, organizational capacity facilitates implementation, and environmental conditions enhance sustainability and scalability. The results therefore provide empirical support for the applicability of the TOE framework in explaining institutional adoption of immersive technologies within the Kenyan TVET context.

Proposed TOE-Based Assessment and Adoption Framework

Based on the empirical findings, a Technology–Organization–Environment (TOE)-based assessment and adoption framework was developed to guide systematic implementation of Virtual Reality in TVET institutions. The framework is grounded on the relative importance of

the TOE dimensions identified through the regression analysis and proposes a three-stage adoption process comprising technological assessment, organizational implementation, and environmental alignment.

The first stage, technological assessment, focuses on evaluating institutional readiness in terms of infrastructure availability, device adequacy, internet connectivity, electricity reliability, compatibility with existing instructional systems, and opportunities for piloting VR initiatives. This stage enables institutions to determine the technical feasibility of VR implementation and identify critical infrastructure gaps before significant investments are made.

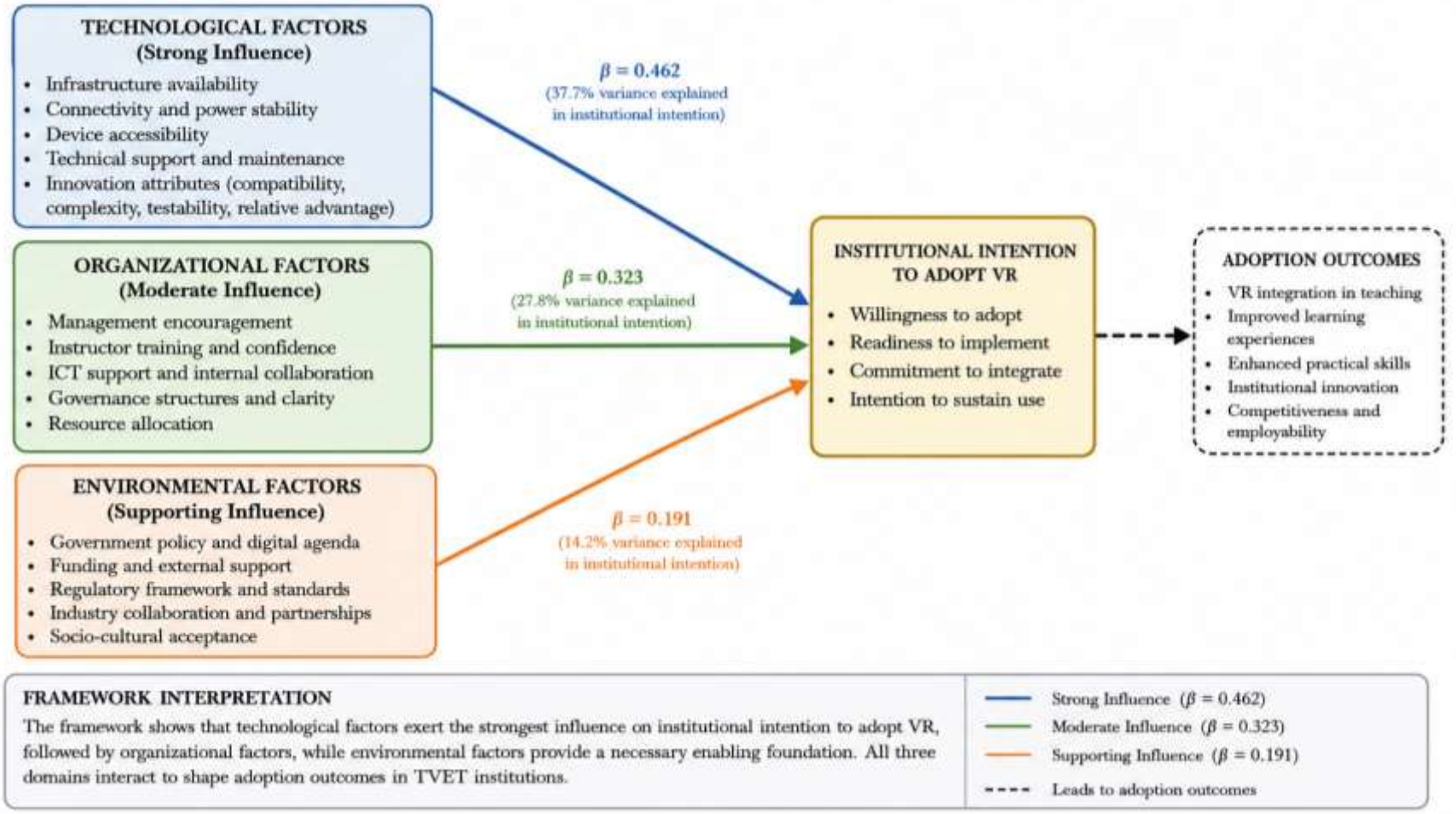
The second stage, organizational implementation, emphasizes development of internal capacity through leadership commitment, instructor training, governance structures, technical support systems, and resource allocation. The findings demonstrated that organizational capacity is essential for translating technological investments into sustained instructional practice. Consequently, institutions should establish structured implementation mechanisms that support curriculum integration and long-term operational sustainability.

The third stage, environmental alignment, focuses on strengthening external support systems through policy alignment, industry partnerships, funding mechanisms, and stakeholder collaboration. Environmental alignment enhances sustainability and scalability by ensuring that institutional VR initiatives are supported by broader regulatory and industry ecosystems.

The proposed framework translates the empirical findings into a practical implementation pathway through which institutions can assess readiness, build organizational capacity, and align with external support systems. By sequencing adoption activities across technological assessment, organizational implementation, and environmental alignment, the framework provides a structured approach for sustainable VR integration within TVET institutions.

The sequencing of the framework reflects the empirical hierarchy observed in the regression model, where technological readiness emerged as the strongest predictor of adoption intention, followed by organizational capacity and environmental support. Consequently, institutions should first establish technological feasibility, then strengthen internal implementation systems, and finally align with external policy and stakeholder ecosystems to ensure sustainability.

Figure 1: Proposed TOE-Based Assessment and Adoption Framework for VR in TVET Institutions



The integrated regression analysis confirms that successful VR adoption in TVET institutions requires a balanced combination of technological readiness, organizational capacity, and environmental support. The proposed TOE-based assessment and adoption framework translates these findings into a practical roadmap that can guide institutional planning, resource allocation, implementation, and long-term sustainability of VR initiatives within the TVET sector.

Conclusion

This study examined the technological, organizational, and environmental factors influencing institutional intention to adopt Virtual Reality (VR) in TVET institutions in Machakos Town Sub-County using the Technology–Organization–Environment (TOE) framework. The findings demonstrated that all three TOE dimensions significantly influence institutional intention to adopt VR, with technological readiness emerging as the strongest determinant, followed by organizational capacity and environmental support. The study concludes that the feasibility of VR adoption is primarily dependent on the availability of adequate infrastructure, reliable connectivity, compatible software, and technical support systems. In addition, leadership commitment, instructor training, governance structures, and institutional support mechanisms were found to be critical for successful implementation, while policy support, funding opportunities, and industry partnerships function as important enabling conditions for sustainability.

The study further concludes that VR adoption in Machakos Town Sub-County TVET institutions is feasible but requires a structured and staged approach. Based on the empirical findings, a TOE-based assessment and adoption framework comprising technological assessment, organizational implementation, and environmental alignment was developed to guide readiness assessment, implementation planning, and long-term sustainability. The framework provides a practical tool for assessing institutional readiness, prioritizing interventions, and sequencing implementation activities to reduce adoption risk and enhance sustainability. However, the framework should be regarded as a preliminary model that requires further validation through expert review and pilot implementation before large-scale application.

Recommendations

The findings suggest that TVET institutions should prioritize technological readiness before attempting full-scale curriculum integration of VR. This includes investment in VR equipment, internet connectivity, power backup systems, software licensing, and technical support mechanisms. A phased implementation approach beginning with pilot VR laboratories is recommended to allow institutions to assess feasibility, costs, and utilization before wider deployment.

Institutional management should strengthen organizational readiness through structured instructor training, clear implementation guidelines, dedicated technical support systems, and formal governance mechanisms for VR integration. Building internal capacity will ensure that VR adoption progresses beyond equipment acquisition to sustainable instructional use.

At the environmental level, stronger collaboration among TVET institutions, industry partners, technology providers, and government agencies is required to support development of locally relevant VR content, improve funding opportunities, and strengthen implementation support. In addition, the proposed TOE-based framework should be applied as a readiness assessment and planning tool and further validated through pilot implementation and Delphi studies involving TVET experts, ICT specialists, curriculum developers, institutional leaders, and policymakers.

Future Research

Future studies should evaluate post-adoption outcomes of VR implementation, including effects on skill acquisition, learner engagement, employability, and long-term sustainability. Further research should also examine user-level factors such as instructor attitudes, digital literacy, self-efficacy, and technology anxiety, and validate the proposed framework through pilot implementation across different TVET contexts.

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