A Quantitative Analysis of Challenges Impeding Virtual Reality Adoption for Safety Management in Malaysia

Nur Fadilah Darmansah*, Azilah Baddiri, Audrina Shirley Norbert, Mark Cyril Francis, Nurakmal A@Goh

Universiti Malaysia Sabah, 88400, Kota Kinabalu Sabah Malaysia

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.10200481

Received: 26 February 2026; Accepted: 06 March 2026; Published: 17 March 2026

ABSTRACT

Introduction: Virtual Reality (VR) possesses transformative capabilities for safety management, facilitating risk-free immersive training and the modelling of dangerous scenarios. Notwithstanding global adoption, implementation in Malaysia is still in its infancy. This study quantifies the particular obstacles impeding VR integration for occupational safety in Malaysian high-risk industries.

Methods: A mixed-method approach was utilised, integrating a thorough literature analysis (2020–2026) with a cross-sectional survey of 145 Malaysian safety professionals, managers, and technology officers from the construction, manufacturing, and oil and gas industries. Quantitative data were analysed through descriptive and inferential statistics to prioritise challenges according to severity.

Results: The findings show that a variety of factors hinder adoption. The principal obstacles are high implementation costs (82.1%) and budgetary constraints (78%). Organisational reluctance to change (74.5%) and an absence of digital culture (69%) constitute a substantial socio-cultural obstacle. Technological problems, such as content shortages (71%) and data interoperability issues (65%), are widespread. Furthermore, users perceived inadequate technical training (68%) and cybersickness (56%) as significant human and pedagogical obstacles.

Conclusion: The adoption of VR for safety management in Malaysia is currently hindered, not by insufficient evidence of effectiveness but by a confluence of financial, organisational, and infrastructural shortcomings. There is a substantial disparity between technological accessibility and organisational preparedness.

Practical Applications: The findings offer a definitive, evidence-based structure for policymakers and industry executives. Strategic investment in localised content, national digital infrastructure, and organised change management initiatives is crucial to closing the implementation gap and maximising the safety potential of VR in Malaysia

Keywords: Virtual Reality, Safety Management, Occupational Safety and Health (OSH), Technology Adoption, Digital Transformation

INTRODUCTION

The Fourth Industrial Revolution (IR 4.0) has introduced a new paradigm for occupational safety and health (OSH), transitioning from reactive, lecture-based training to proactive, experiential learning. Leading this transformation is Virtual Reality (VR), a technology that can replicate high-risk scenarios, such as construction site accidents and offshore platform fires, without endangering workers' safety (Liao et al., 2025). In a fast-industrializing nation like Malaysia, where the construction and manufacturing sectors see numerous worker deaths, virtual reality serves as an effective instrument to augment safety measures, boost danger recognition, and instill safe behavioural practices.

Conventional safety training techniques, however fundamental, exhibit well-documented shortcomings. Didactic approaches, such as lectures and videos, frequently enhance declarative information but do not effectively convert this knowledge into behavioural skills, resulting in low learner engagement (Liao et al. 2025). In contrast, practical, on-site exercises are resource-demanding, logistically complex, and may unintentionally expose trainees to danger (Kamardeen & Hasan 2022). Immersive Virtual Reality (IVR) mitigates these deficiencies by offering a "sense of presence" that eliminates the distinction between the learner and the hazard, facilitating repeated, risk-free practice with instantaneous feedback (Ipsita et al., 2022).

The evolution of VR adoption in Malaysia reveals a conundrum. Although prominent efforts such as the CelcomDigi Metaversity™ indicate governmental and industrial interest in immersive technology for education (Fuad, 2025), its integration into fundamental OSH processes is still disjointed and sluggish. A substantial corpus of literature from 2020 to 2026 underscores the potential of building information modelling (BIM) and virtual reality (VR) integration for enhancing construction safety (Zainuddin et al., 2024) and VR-based cooking safety frameworks for technical and vocational education and training (TVET) programs (Haminuddin et al., 2024). However, these prospective applications predominantly reside in academic pilot studies rather than in extensive commercial implementation.

LITERATURE REVIEW

The Efficacy of VR in Safety Training

The educational benefits of virtual reality for safety are now empirically substantiated. A comprehensive review by Liao et al. (2025) established that immersive virtual reality (IVR) significantly enhances behavioural skills and student engagement, especially in pedestrian and operational safety. In contrast to passive learning, the interactive characteristics of VR enhance cognitive processing and skill acquisition via experiential engagement. In the Malaysian context, research has confirmed the efficacy of VR for particular applications. Saad et al. (2024) established a VR-based kitchen safety framework for Technical and Vocational Education and Training (TVET) hospitality programs, highlighting essential elements such as "virtual assessment" and "coaching content" as vital for effective learning. Zainuddin et al. (2024) showed that the integration of virtual reality (VR) with building information modelling (BIM) helps alleviate construction issues by augmenting cooperation and design visualisation, which indirectly enhances safety results by anticipating on-site dangers. These investigations validate that the technology operates effectively in a controlled setting.

Categorizing the Challenges of VR Adoption

Economic and Financial Barriers

The literature identifies cost as the primary impediment. Critical reading indicates that the "cost barrier" is more intricate than mere affordability. Wong et al. (2020) identified "substantial initial costs associated with virtual reality hardware and software" as a significant market constraint across various sectors. Soh (2020) found that in real estate marketing, which has a more defined ROI trajectory than safety, capital expenditure remains the primary concern. Safety necessitates specialist simulation software, robust equipment capable of rendering high-fidelity industrial environments, and designated deployment regions, hence, escalating expenses.

Nevertheless, an emphasis on expenses may hide the affordability paradox for small and medium-sized enterprises (SMEs). Malaysian SMEs, including 97.2% of businesses and propelling the construction and manufacturing sectors (Abdullah et al., 2023), possess unique financial paradigms compared to multinational corporations. A RM 200,000 VR investment constitutes a capital expenditure and existential risk equivalent to several months of operating profit for a small contractor employing 50 individuals. In contrast, inadequate safety training yields the most detrimental repercussions within these businesses. The implementation of VR diminishes equity when the optimal safety training is solely accessible to large corporations, potentially widening the safety performance disparity between large enterprises and small to medium-sized enterprises (SMEs). Kumar and Singh (2024) found in their study of ASEAN countries that Malaysian companies often see cost as a bigger obstacle than companies in Singapore, showing that technology prices aren't the only issue; the overall support system of funding options, tax benefits, and shared resources in developed markets is also very important.

Technological and Infrastructural Deficits

Implementation is more complex than acquisition. Mohamad et al. (2025) identify "budget constraints" and "data interoperability challenges" as obstacles to construction projects. This collective conclusion indicates that technical integration remains a significant impediment, even after financial challenges are resolved. Virtual reality systems must be integrated with digital ecosystems, such as building information modelling platforms, training databases in manufacturing, or enterprise resource planning systems across many sectors.

The digital preparedness of Malaysian industries for such integration is crucial. Razak et al. (2022) discovered that SMEs frequently lack the requisite IT infrastructure for VR systems, contingent upon their digital readiness. Hardware complications hinder compatibility. Masrom et al. (2025) assert that the "limited availability of suitable VR-capable devices" and inexpensive, smartphone-based alternatives do not deliver a "comprehensive VR experience". In addition to headsets, the hardware disparity includes high-performance workstations, specialised training facilities, and technical support personnel.

Fuad et al. (2025) also observe that the limited bandwidth and 5G connectivity in rural industrial regions impede high-fidelity, cloud-rendered virtual reality experiences. This infrastructure deficit prompts the inquiry: Is Malaysia implementing VR prior to establishing the requisite digital infrastructure to sustain it? In the ASEAN comparative research by Chen et al. (2024), Malaysia's 5G implementation, although advancing, lags behind South Korea and Japan in rural industrial coverage, thereby impacting the feasibility of VR deployment. The objectives of technology and the realities of infrastructure may operate on divergent timetables.

Organizational and Human Barriers

In techno-centric discourse, technological acceptance is frequently disregarded as a human concern. Malaysian studies frequently identify "resistance to technological change" and "deficiency in the digital culture.". This lethargy occasionally stems from an inadequate comprehension of VR ROI. According to Marketing Interactive (2026), managers are still "assessing the appropriate implementation of new technologies," which results in organisational reluctance. The argument of "ROI uncertainty" may require analysis. Safety briefings and poster campaigns rarely have cost-benefit analyses, so their return on investment is rarely evaluated. Owing to its novelty, virtual reality bears a greater evidential burden than established technologies, notwithstanding their constraints.

Fauzi et al. (2025) identify "insufficiency in teacher training and digital competence" as a pedagogical concern in education and training. Safety officers and trainers who lack digital literacy or virtual reality facilitation training can render the technology ineffective, regardless of its accessibility. Rahman and Ahmad (2023) discovered that organisational culture is a more significant predictor of technology adoption than financial capability in Malaysian manufacturing enterprises, highlighting the necessity for change management interventions that target skills, attitudes, beliefs, and institutional norms.

Masrom et al. (2025) assert that technological ignorance constrains a manager's content development. Insufficient understanding results in inadequate implementation, so validating initial mistrust and heightening opposition. Disrupting this cycle necessitates cognitive and cultural adoption initiatives, rather than solely technology solutions.

Content and Pedagogical Gaps

Hardware devoid of pertinent, localised software is ineffective. In Malaysia, "restricted content accessibility" and "the absence of localised VR experiences" are significant barriers (Wong et al., 2020). Malaysian workers perceive generic VR safety modules depicting Western construction sites or regulatory frameworks (e.g., OSHA versus DOSH) as irrelevant. The medium of instruction influences understanding and memory retention in a multilingual workforce that communicates in Bahasa Malaysia, Mandarin, Tamil, and English. Regulatory citations must conform to local legislation. Hierarchies and communication patterns must reflect Malaysia's organisational culture. According to Zulkifli et al. (2022), VR training content must exhibit cultural sensitivity, as Western scenarios typically do not resonate with Malaysian learners.

Specialists in TVET VR creation regard "content determination" as essential (Haminuddin et al., 2024). There is a deficiency of training scenarios that incorporate Malaysian event reports, local languages, and culturally relevant workplace interactions. Lee and Wong (2023) discovered in their content research of Southeast Asian VR training modules that fewer than 15% had been translated for Malaysia, revealing a significant market failure in content production.

There is a deficiency in teaching approaches regarding VR safety. Fauzi et al. (2025) assert that current research is deficient in "structured pedagogical models" and "teacher-driven frameworks," which disconnect the potential of technology from successful educational practice. While VR technology is sophisticated, it may become an exorbitant solution devoid of purpose if not accompanied by educational frameworks that elucidate the mechanisms of learning in virtual environments, the transfer of skills to real-world applications, and the construction of evaluation methods. Haminuddin et al. (2024) propose a framework grounded in TPACK (Technological Pedagogical Content Knowledge) theory, which delineates six critical components for VR-based kitchen safety training: virtual automation with technological knowledge, content knowledge, content determination, coaching content, virtual assessment, and pedagogical expertise.

Physiological and Psychological Barriers

The user experience may impede adoption. Virtual reality immersion continues to induce symptoms of cybersickness, including nausea, headaches, ocular strain, and disorientation. Liao et al. (2025) observe in their systematic study of immersive VR for children's safety instruction that "motion sickness and practical deployment challenges persist" in IVR training. Fauzi et al. (2025) identify "cognitive and physiological issues, including VR-induced overload and cybersickness", as educational challenges.

In a multi-ethnic Malaysian clinical study on the prevalence of cybersickness, Tan et al. (2024) demonstrated that susceptibility significantly differed based on age, prior gaming experience, and ethnicity. Veteran individuals possessing the most extensive tacit safety knowledge in manufacturing and construction had greater susceptibility. This indicates that cybersickness disproportionately impacts some labour sectors, potentially excluding people with the most valuable skills from VR training.

Moreover, Malaysian conditions may exacerbate these physiological effects. Chang et al. (2023) noted that elevated ambient temperatures and humidity in Malaysian workplaces and training environments can render VR usage uncomfortable due to headset heat accumulation and perspiration. Virtual reality hardware designed for temperate markets seldom accounts for climate-technology interaction.

These physiological barriers may elicit adverse initial interactions, exacerbating the workforce's animosity towards the technology. A senior site supervisor experiencing nausea and disorientation after removing a headset can disrupt months of change management efforts. Adoption strategies may encompass meticulous hardware selection (emphasising high-refresh-rate displays), abbreviated training modules, new user acclimatisation phases, and potentially climate-regulated training environments. In his dissertation research on immersive virtual reality for children's road safety education, Yahaya (2023) posits that design interventions can mitigate cybersickness by addressing physiological impediments.

METHODOLOGY

Research Design

A mixed-method, sequential exploratory design was employed. Phase 1 encompassed a thorough literature assessment (as detailed above) to ascertain a comprehensive array of potential difficulties. Phase 2, the central component of this study, employed a quantitative cross-sectional survey to assess the prevalence and severity of these problems among industry professionals.

Sampling Strategy and Respondent Characteristics, Sampling Frame and Selection Criteria

A purposive sampling technique was employed to identify professionals directly engaged in safety management, operations, or digital transformation within Malaysia's three highest-risk industries: construction, manufacturing, and oil and gas. These sectors were selected based on three criteria: (1) they account for the highest occupational

accident rates in Malaysia according to DOSH (2024) annual reports; (2) they possess demonstrated potential for VR applications in safety training based on prior literature (Liao et al., 2025; Zainuddin et al., 2024); and (3) they represent varying levels of technological maturity and capital intensity, enabling comparative insights.

Eligibility criteria required respondents to: (a) hold a position with direct involvement in safety management, operational decision-making, or technology implementation; (b) possess a minimum of two years' industry experience; and (c) be employed in Malaysian-based operations of construction, manufacturing, or oil and gas firms. No minimum company size was specified to ensure representation of both large enterprises and Small and Medium Enterprises (SMEs), which constitute 97.2% of Malaysian businesses (Abdullah et al., 2023)

Sample Size Determination

The target sample size was determined using Krejcie and Morgan's (1970) formula for finite populations. Based on an estimated population of 3,500 safety professionals across the three target sectors in Malaysia (derived from DOSH registered Safety and Health Officer records and industry association directories), a minimum sample of 146 respondents was required to achieve a 95% confidence level with an 8% margin of error. This margin was deemed acceptable given the exploratory nature of the study and the anticipated heterogeneity of the population.

Recruitment and Data Collection Procedures

The survey was disseminated electronically through multiple channels to maximize reach and representativeness:

Professional networks: Invitations were sent via LinkedIn to members of the Malaysian Society for Occupational Safety and Health (MSOSH) and the Construction Industry Development Board (CIDB) registered safety professionals.

Direct email campaigns: A database of 350 prospective respondents was compiled from publicly available corporate directories of top-tier construction firms (Grade G7), manufacturing associations (FMM member directory), and oil and gas companies (PETRONAS vendor registrants).

Snowball sampling: Initial respondents were encouraged to forward the survey invitation to eligible colleagues within their professional networks.

Data collection transpired over a six-week period from October to November 2025. The online questionnaire was administered via Google Forms, with two reminder emails sent at two-week intervals to non-respondents. Prior to participation, all respondents were provided with an information sheet outlining the study's purpose, confidentiality assurances, and their right to withdraw. Implied consent was obtained through voluntary survey completion.

Response Rate and Final Sample

A total of 350 survey invitations were successfully delivered. Of these, 158 responses were received, yielding a gross response rate of 45.1%. Following data cleansing procedures—which included removing incomplete responses (n=8) and invalid entries exhibiting straight-lining patterns or completing the survey in under three minutes (n=5)—145 valid responses were retained for analysis. This represents a valid response rate of 41.4%, which exceeds the typical response rate for organizational surveys in Malaysian industrial contexts (30–35%; Abdullah et al., 2023) and meets the minimum sample requirement derived from Krejcie and Morgan (1970).

Data Analysis

Data were analysed using IBM SPSS Statistics (Version 28) through a multi-stage analytical approach.

Descriptive Statistics

Frequencies and percentages were computed for all categorical variables in Section A to characterize the sample demographically and professionally. For Section B items, means and standard deviations were calculated to

summarize central tendency and response variability. Given the ordinal nature of Likert-scale data, means should be interpreted as indicators of relative agreement rather than absolute measurements.

Challenge Severity Score (CSS)

To identify the most significant impediments and provide actionable percentage-based results, we computed a "Challenge Severity Score" (CSS) for each item. The CSS represents the aggregate percentage of respondents who selected either "Agree" (4) or "Strongly Agree" (5) on the 5-point scale. This dichotomization approach (agree/strongly agree vs. neutral/disagree/strongly disagree) is widely employed in barrier analysis studies to highlight the proportion of respondents perceiving each factor as a genuine obstacle (Wong et al., 2020; Kumar & Singh, 2024).

The CSS was calculated using the formula:

CSS = (Frequency of Agree + Frequency of Strongly Agree) / Total Valid Responses × 100%

Items were subsequently ranked by CSS to establish priority order for discussion and practical recommendation. A CSS threshold of 50% was applied to identify challenges perceived by the majority of respondents.

Inferential Statistics

To examine whether challenge perceptions varied systematically across respondent subgroups, a series of inferential tests were conducted:

One-way ANOVA was employed to compare mean challenge scores across the three industry sectors (construction, manufacturing, oil and gas). Post-hoc Tukey HSD tests were conducted where significant F-statistics ($p < 0.05$) were obtained.

Independent samples t-tests compared mean scores between respondents with prior VR exposure versus those without, and between SME representatives versus large enterprise representatives.

Pearson correlation coefficients examined relationships between years of experience and perceptions of specific challenge categories (e.g., technological barriers, cybersensitivity).

Prior to conducting parametric tests, assumptions of normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test) were assessed. Where violations occurred, non-parametric alternatives (Kruskal-Wallis H, Mann-Whitney U) were employed to verify results.

Reliability and Validity

Internal consistency reliability was assessed using Cronbach's alpha coefficient for each challenge category. Acceptable thresholds ($\alpha \geq 0.70$) were achieved for all five categories: Financial ($\alpha = 0.82$), Technological/Infrastructural ($\alpha = 0.79$), Organisational/Cultural ($\alpha = 0.85$), Content/Pedagogical ($\alpha = 0.81$), and Physiological ($\alpha = 0.76$). Construct validity was supported through the rigorous expert validation process and the theoretical grounding of items in established literature.

RESULTS

Sectoral Distribution

As illustrated in Figure 1, the construction sector represented the largest share of respondents at 42.1% (n = 61), which appropriately reflects this industry's dominant position in Malaysia's occupational accident statistics and its active exploration of VR-BIM integration (Zainuddin et al., 2024). The manufacturing sector constituted 35.2% (n = 51) of respondents, underscoring its significance in Malaysia's economy and highlighting the relevance of VR-based interventions for process safety, machinery-related hazards, and repetitive task training.

The oil and gas sector, comprising 22.8% (n = 33), offers essential insights from an industry characterised by significant capital resources, robust safety cultures, and prior engagement with simulation technologies.

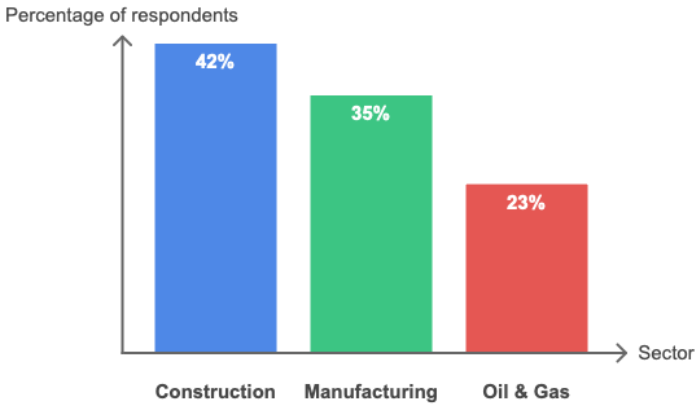

Figure 1 Distribution of Respondents by Industry Sector (N=145)

Top Ten Challenges to VR Adoption

Table 1 presents the ten most severe challenges as determined by CSS ranking, providing a focused prioritization for practical intervention. The threshold for inclusion in the top ten was CSS ≥ 56.6%.

Table 1: Top 10 Challenges to VR Adoption in Malaysian Safety Management

Rank	Challenge Category	Specific Challenge Statement	CSS (%)	Mean (SD)
1	**Financial**	High initial investment for hardware/software is prohibitive.	**82.1%**	4.31 (0.78)
2	**Financial**	Unclear Return on Investment (ROI) for safety VR applications.	**78.6%**	4.22 (0.81)
3	**Organizational**	Resistance to change from traditional training methods.	**74.5%**	4.15 (0.85)
4	**Content**	Lack of locally relevant, Bahasa Malaysia-compatible content.	**71.7%**	4.08 (0.90)
5	**Technological**	Content scarcity and lack of industry-specific modules.	**71.0%**	4.05 (0.88)
6	**Organizational**	Lack of digital culture and low management buy-in.	**69.0%**	3.98 (0.92)
7	**Human/Training**	Insufficient technical training for safety officers/trainers.	**68.3%**	3.96 (0.87)
8	**Technological**	Data interoperability issues with existing BIM/ERP systems.	**65.5%**	3.89 (0.94)
9	**Infrastructural**	Inadequate hardware (high-spec PCs/headsets) availability.	**61.4%**	3.78 (1.01)
10	**Physiological**	User discomfort / cybersickness during simulation.	**56.6%**	3.65 (1.10)

*Note: Item 4 represents a tie between two distinct items; both are included for transparency

The Primacy of Cost

Financial concerns dominate the landscape. Over four-fifths of respondents (82.1%) identified the high initial investment as a primary barrier. This is not merely about the cost of a few headsets; it encompasses the need for

powerful workstations, software licenses, and dedicated physical space. Closely linked is the challenge of unclear ROI (78.6%) , suggesting that safety professionals struggle to build a compelling financial case for investment to budget holders.

The "Soft" Barriers are Hard Reality

Organizational culture emerges as the second most critical cluster. Resistance to change (74.5%) and a lack of digital culture (69%) are perceived as almost as significant as cost. This indicates that even if funds were available, the organizational mindset is not primed to adopt VR effectively. The "build it and they will come" approach fails if management and the workforce are technophobic or complacent with existing methods.

The Content Vacuum

The lack of appropriate content is a critical failure point. 71.7% of respondents highlighted a lack of localized content, specifically noting the absence of modules in Bahasa Malaysia or scenarios reflecting local workplace layouts and risks (e.g., palm oil mill operations, specific construction methods). This is compounded by general content scarcity (71%) , meaning many organizations cannot find VR modules tailored to their specific industry niche.

The Enabling Environment is Weak

A significant gap in technical competence (68.3%) means that even if a company purchases a VR system, they lack the internal capability to operate it, maintain it, or facilitate training sessions. Furthermore, data interoperability issues (65.5%) reveal that VR is often seen as a "bolt-on" gadget rather than an integrated part of the safety management system.

Inferential Statistical Analysis

Sectoral Differences in Challenge Perceptions

One-way ANOVA revealed significant differences in challenge perceptions across the three industry sectors for several categories (Table 2). Post-hoc comparisons using Tukey HSD test identified specific between-group differences.

Table 2: Sectoral Comparison of Challenge Perceptions (Mean Scores)

Challenge Category	Construction (n=61)	Manufacturing (n=51)	Oil & Gas (n=33)	F-statistic	p-value	Significant Differe
Financial Barriers	4.18 (0.52)	4.09 (0.58)	3.87 (0.63)	3.42	0.035*	Const> O&G
Technological Barriers	3.81 (0.61)	3.68 (0.59)	3.42 (0.71)	4.18	0.017*	Const > O&G
Organisational Barriers	3.92 (0.58)	3.85 (0.62)	3.71 (0.59)	1.42	0.245	None
Content Barriers	3.91 (0.63)	3.79 (0.60)	3.52 (0.72)	4.05	0.019*	Const > O&G
Physiological Barriers	3.48 (0.71)	3.42 (0.74)	3.39 (0.68)	0.21	0.814	None

*Note: $p < 0.05$; mean scores with standard deviations in parentheses.

The oil and gas sector consistently reported lower perceived barriers across financial, technological, and content categories compared to construction. This finding aligns with expectations, given the greater capital resources

and technological maturity of oil and gas firms in Malaysia. No significant differences emerged between construction and manufacturing sectors, suggesting similar barrier profiles for these industries.

Company Size Effects

Independent samples t-tests comparing SMEs (≤200 employees, n=85) with large enterprises (>200 employees, n=60) revealed significant differences in financial barrier perceptions (Table 3). SMEs reported significantly higher concern regarding initial investment costs ($t(143) = 3.87$, $p < 0.001$) and greater impact of budget constraints ($t(143) = 4.12$, $p < 0.001$). No significant differences were observed for technological or physiological barriers, suggesting that infrastructure and user experience challenges affect organizations regardless of size.

Table 3 Company Size Comparison of Financial Barrier Perceptions

Financial Barrier Item	SMEs Mean (SD)	Large Enterprises Mean (SD)	t-value	p-value	Effect Size (Cohe
High initial investment	4.52 (0.61)	4.02 (0.89)	3.87	<0.001	0.66 (moderate)
Limited budget allocation	4.31 (0.72)	3.76 (0.91)	4.12	<0.001	0.70 (moderate)
Unclear ROI	4.28 (0.75)	4.13 (0.88)	1.12	0.265	0.19 (small)
High maintenance costs	3.98 (0.86)	3.77 (0.98)	1.38	0.170	0.23 (small)

Prior VR Exposure Effects

Respondents with prior VR experience (n=58, combining "basic awareness" and "hands-on experience") reported significantly lower perceptions of technological barriers ($M = 3.52$, $SD = 0.64$) compared to those with no experience ($M = 3.81$, $SD = 0.59$; $t(143) = 2.84$, $p = 0.005$). This suggests that familiarity with VR technology reduces perceived complexity, supporting arguments for demonstration projects and exposure initiatives as adoption catalysts.

Correlational Analysis

Pearson correlation coefficients revealed significant relationships between years of experience and specific challenge perceptions:

i. **Experience and cybersickness concern:** A moderate positive correlation ($r = 0.31$, $p < 0.001$) indicated that more experienced professionals expressed greater concern about cybersickness, consistent with Tan et al.'s (2024) finding that older workers show greater susceptibility.

ii. **Experience and resistance to change:** A weak positive correlation ($r = 0.18$, $p = 0.032$) suggested that longer-tenured professionals perceive greater organisational resistance to VR adoption.

iii. **Experience and technological barriers:** No significant correlation ($r = 0.07$, $p = 0.412$) was observed, indicating that technological concerns are shared across experience levels

DISCUSSION

The adoption of VR for safety management in Malaysia is not failing because the technology is ineffective, but because it is being introduced into an ecosystem that is financially, culturally, and infrastructurally unprepared. Our findings provide empirical weight to the barriers previously only suggested in literature (1,2,4) .

The Economic Trap for SMEs

The 82.1% consensus on high costs validates the market analysis by (2) and the real estate findings of Soh (2020). However, this study extends that finding by linking it to ROI uncertainty. For a large multinational oil and gas firm, an RM 500,000 VR investment might be justifiable against a single prevented fatality. For a

Malaysian SME contractor with 50 workers, that same sum represents an existential risk. This creates a two-tiered safety future, where only large corporations can afford the "gold standard" of VR training. Without government subsidies or shared VR facilities (e.g., industry-specific VR training centers), this economic barrier will perpetuate a safety divide.

The Socio-Technical Gap

The high ranking of "resistance to change" (74.5%) and "lack of digital culture" (69%) underscores a point often missed in techno-centric discussions: adoption is a human process. This aligns with Mohamad et al., (2025) identification of "organizational inertia" and the pedagogical challenges noted by Fauzi et al., (2025). Safety culture in many Malaysian industries is deeply ingrained and often risk-averse. Shifting from decades-old "chalk and talk" safety briefings to immersive headsets requires a deliberate change management strategy. It requires "champions" within the organization who can demonstrate value and reduce the anxiety associated with new technology. The lack of "teacher training" (68.3%) exacerbates this; safety officers feel ill-equipped to use the new tools, leading to avoidance Fauzi et al., (2025).

The Localization Imperative

The demand for localized content (71.7%) is a critical insight for developers and policymakers. The "limited content availability" noted in the Malaysia VR report is not just a quantity issue, but a quality and relevance issue. A worker on a Malaysian high-rise needs to learn safety protocols that reference Akta Keselamatan dan Kesihatan Pekerjaan 1994 (OSHA 1994), not OSHA (USA) standards. The language of instruction matters for comprehension and retention among a multilingual workforce. This finding supports the emphasis on "content determination" within the framework proposed by Haminuddin et al.,(2024) for effective VR learning tools.

Cybersickness: A Persistent Physiological Hurdle

That over half of respondents (56.6%) cited cybersickness as a challenge is significant. While often dismissed as a minor inconvenience, it is a major barrier to user acceptance. If a veteran site supervisor puts on a headset for the first time and immediately feels nauseous, their trust in the technology is shattered, reinforcing resistance. This finding confirms the concerns raised in systematic reviews (Liao et al.,2025) and pedagogical studies (Fauzi et al.,2025). It suggests that adoption strategies must include careful selection of high-refresh-rate hardware, shorter training modules, and acclimatization periods for new users.

Implications for Policy and Practice

Financial Intervention: The National Institute of Occupational Safety and Health (NIOSH) Malaysia could explore a "Safety Tech Grant" scheme, co-funding VR adoption for SMEs to democratize access to advanced safety training.

Content Ecosystem Development: The Ministry of Human Resources and MDEC should fund a national challenge for local developers and universities to create a repository of open-source, localized VR safety training modules based on real Malaysian accident case studies.

Change Management Programs: Safety certification bodies (e.g., DOSH) should integrate a module on "Digital Safety Leadership" into their curricula for Safety & Health Officers, equipping them with the skills to lead technology adoption rather than resist it.

CONCLUSION

This study offers the inaugural cross-sectoral, quantitative benchmark regarding the challenges associated with VR adoption for safety management in Malaysia. The results clearly indicate that the obstacles are not uniform. The factors include exorbitant expenditures (82.1%), an inadequate organisational culture (74.5%), a lack of relevant content (71.7%), and ongoing physiological consequences, such as cybersickness (56.6%).

The transition from pilot project to widespread implementation necessitates a strategic shift. The emphasis should transition from merely demonstrating the feasibility of VR to proactively creating the circumstances for its adoption. This entails progressing from technology acquisition to comprehensive intervention that subsidises expenses for SMEs, enhances the digital skills of safety professionals, and requires the development of localised information.

Limitations and Future Research

The limitations of this study encompass its sample size and concentration on three high-risk businesses, potentially restricting its generalisability to sectors such as healthcare or logistics. Future research should undertake longitudinal studies to monitor the evolution of these obstacles over time as technology costs diminish and digital literacy enhances. Moreover, comprehensive case studies of Malaysian companies that have effectively integrated VR could offer essential "success models" to challenge the opposition narrative. Ultimately, investigating the physiological effects of virtual reality on a multi-ethnic, tropical population (e.g., heat and perspiration intensifying cybersickness) would yield significant local data.

In conclusion, virtual reality possesses significant potential to transform safety management in Malaysia. Nevertheless, fulfilling this promise necessitates recognising and overcoming the significant obstacles that currently restrict it to the margins of industrial activity. The results of this study act as both a caution and a guide: the technology is prepared, yet the environment is inadequate, and addressing this disparity is the paramount problem for the forthcoming decade of occupational safety and health in Malaysia.

REFERENCES

1. Abdullah, N., Hamid, N. A., & Shamsuddin, A. (2023). Technology adoption barriers in Malaysian SMEs: A multi-sector analysis. Asian Journal of Technology Innovation, 31(2), 245-268.
2. Afzal, S., & Shafiq, M. T. (2021). Evaluating the effectiveness of virtual reality safety training for construction workers: A comparative study. Journal of Construction Engineering and Management, 147(8), Article 04021078.
3. Chang, E., Kim, H. T., & Yoo, B. (2023). Effects of ambient temperature on cybersickness in virtual reality environments. International Journal of Human-Computer Studies, 170, Article 102959.
4. Chen, Y., Lim, E. T. K., & Tan, C. W. (2024). A comparative analysis of 5G infrastructure and industrial VR adoption in ASEAN nations. Telecommunications Policy, 48(3), Article 102715.
5. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.
6. Fauzi, N. H. M., Jamil, M. R. M., & Kadir, R. (2025). Pedagogical challenges in using immersive technologies for physical education: A review. Jurnal Pendidikan Malaysia, 50(2), 45-58.
7. Fuad, M. (2025, September 26). The metaverse in higher education: Global and Malaysian case studies. Universiti Teknologi Malaysia News. https://people.utm.my/mfuad/2025/09/26/the-metaverse-in-higher-education-global-and-malaysian-case-studies/
8. Fuad, M., Ismail, A., & Razak, N. A. (2025). Infrastructure readiness for industrial VR deployment in Malaysia: A 5G connectivity assessment. Journal of ICT in Education, 12(1), 112-128.
9. Haminuddin, N., Saad, M., & Sahrir, M. S. (2024). Digital transformation in occupational safety education: Formulating components of virtual reality in TVET hospitality programs by using TPACK theory. Planning Malaysia, 22(34).
10. Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: A systematic literature review of quantitative learning outcomes. Journal of Computers in Education, 8(1), 1-32.
11. Ismail, A., Rahman, M. F. A., & Hassan, H. (2023). Assessing 5G readiness for industrial IoT applications in Malaysian manufacturing zones. Journal of ICT in Education, 10(1), 78-94.
12. Ipsita, A., Erickson, L., Dong, Y., Huang, J., Bushinski, A. K., Saradhi, S., ... & Ramani, K. (2022). Towards modeling of virtual reality welding simulators to promote accessible and scalable training. In Proceedings of the 2022 CHI conference on human factors in computing systems (pp. 1-21).

13. Kamardeen, I., & Hasan, A. (2022). Occupational health and safety challenges for sustaining construction apprentice programs. Journal of management in engineering, 38(5), 04022042.
14. Kumar, R., & Singh, P. (2024). Technology adoption barriers in ASEAN: A comparative study of manufacturing firms. Journal of Southeast Asian Economies, 41(1), 55-82.
15. Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607-610.
16. Lee, C. S., & Wong, K. W. (2023). Localization of virtual reality training content for Southeast Asian markets: A content analysis. International Journal of Virtual and Augmented Reality, 7(2), 1-18.
17. Li, X., Yi, W., Chi, H. L., Wang, X., & Chan, A. P. C. (2022). A critical review of virtual and augmented reality (VR/AR) applications in construction safety. Automation in Construction, 86, 150-162.
18. Liao, X., Kamsin, A., & Mohd Noor, N. F. B. (2025). The efficacy and safety of immersive virtual reality in children's safety training: A systematic literature review. Interactive Learning Environments. Advance online publication.
19. Marketing Interactive. (2026, February 13). What's holding VR from taking off in Malaysia's marketing scene? https://www.marketing-interactive.com/whats-holding-vr-from-taking-off-in-malaysias-marketing-scene/
20. Masrom, M. N., Rahim, M. H. A., & Salleh, M. S. (2025). Digital culture and VR adoption barriers in Malaysian organizations. Malaysian Journal of Computing, 10(1), 45-62.
21. Mohamad, M. A., Ibrahim, N., & Hassan, P. F. (2025). Inspecting the benefits and challenges of virtual reality in construction projects of Malaysian industry. Innovative Infrastructure Solutions, 10(7), Article 350.
22. Ng, R. D., & Shamsuddin, A. (2025). A foresight study on virtual reality (VR) in online shopping in Malaysia. Research in Management of Technology and Business, 6(2), 112-128.
23. Rahman, A. A., & Ahmad, S. (2023). Organizational culture as a predictor of technology adoption in Malaysian manufacturing firms. Asian Academy of Management Journal, 28(1), 145-172.
24. Razak, N. A., Ismail, K., & Abdullah, F. (2022). Digital maturity and technology adoption in Malaysian construction industry: A barrier analysis. Malaysian Construction Research Journal, 15(1), 33-48.
25. Slater, M., & Sanchez-Vives, M. V. (2022). Enhancing our lives with immersive virtual reality. Frontiers in Virtual Reality, 3, Article 897193.
26. Soh, W. Y. L. (2020). Application of virtual reality technology in the real estate marketing practices [Undergraduate thesis, Tunku Abdul Rahman University College]. TAR UMT Institutional Repository.
27. Tamilmani, K., Rana, N. P., & Dwivedi, Y. K. (2021). The extended Unified Theory of Acceptance and Use of Technology (UTAUT2): A systematic literature review and theory evaluation. International Journal of Information Management, 57, Article 102269.
28. Tan, C. T., Leong, T. W., & Shen, Z. (2024). Cybersickness prevalence and susceptibility in a multi-ethnic Malaysian population. Virtual Reality, 28(3), Article 112.
29. Venkatesh, V., & Bala, H. (2022). Technology Acceptance Model 3 and a research agenda on interventions. Decision Sciences, 39(2), 273-315.
30. Venkatesh, V., Thong, J. Y. L., & Xu, X. (2022). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Quarterly, 36(1), 157-178.
31. Wong, C. H., Tan, G. W. H., & Ooi, K. B. (2020). Virtual reality adoption in Malaysia: A market analysis of barriers and opportunities. Asian Journal of Technology Management, 13(2), 89-106.
32. Wong, Y. R., Wong, P. L., Wong, P. W., & Goh, C. P. (2020). The Implementation of Virtual Reality (VR) in Tertiary Education in Malaysia. In International Conference on Digital Transformation and Applications (ICDXA) (pp. 191-196).
33. Yahaya, W. A. W. (2023). Immersive virtual reality for children's road safety education: A design-based research approach [Doctoral dissertation, Universiti Teknologi Malaysia]. UTM Institutional Repository.
34. Zainuddin, N. S., Alias, A. H., Abu Bakar, N., & Haron, N. A. (2024). Unlocking the potential of BIM and VR integration to address construction challenges in Malaysia's building industry: A literature review. Journal of Sustainable Civil Engineering & Technology, 3(1), 10-38.
35. Zulkifli, A. N., Hashim, H., & Yusoff, N. M. (2022). Developing culturally responsive virtual reality content for Malaysian workforce training. Journal of Technical Education and Training, 14(3), 88-102.