

Article

From Skepticism to Adoption: Assessing Virtual Reality Readiness Among Emerging Architectural Professionals in a Developing Economy

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Abstract

Virtual Reality (VR), particularly when integrated with Building Information Modeling (BIM), is transforming architectural practice in developed economies. However, its adoption in developing countries remains limited due to infrastructural, economic, and organizational challenges. This study addresses this gap by empirically evaluating VR readiness among emerging architectural professionals in Oman through a novel integrated framework. This framework combines the Unified Theory of Acceptance and Use of Technology (UTAUT), which focuses on functional drivers like usefulness, with Presence Theory, which captures experiential drivers like immersion. Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to analyze the survey data and assess VR readiness. The analysis revealed that prior VR exposure significantly predicts adoption intention, a relationship that is partially mediated by perceived usefulness. Organizational support emerged as a key moderator, effectively mitigating the impact of technical barriers on adoption decisions. The model explained the variance in adoption intention, highlighting that experiential familiarity, functional evaluation, and institutional support were critical for advancing digital transformation. The findings provide actionable insights for educational institutions, policymakers, and industry stakeholders aiming to prepare the next generation of architects in Oman and similar economies for VR adoption. By validating a dual-pathway adoption framework, this research contributes both theoretically and practically to understanding immersive technology assimilation in resource-constrained professional contexts.

Keywords: virtual reality; technology adoption; emerging architectural professionals developing economies; Oman



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1. Introduction

Virtual Reality (VR) technologies are reshaping architectural workflows globally, enabling immersive design visualization and enhanced stakeholder collaboration. In developed economies, VR—often integrated with Building Information Modeling (BIM)—has been widely adopted for design validation, client presentations, and safety training, yielding measurable efficiency gains [1]. However, adoption in developing countries remains limited due to infrastructural, economic, and organizational constraints [2]. Significant disparities in VR adoption persist between developed and developing economies. Firms in developed countries show high technical readiness (~90% have VR hardware) and client demand (~68% of projects), enabling routine use. In contrast, firms in developing regions face

substantial barriers: limited technical infrastructure (~32–40% have compatible hardware), limited training (~25% of firms), and low client demand (~12% of projects). These systemic gaps (Table 1) critically hinder implementation, while a literature focus on advanced economies leaves a gap in understanding adoption in resource-constrained environments.

Table 1. Comparative Overview of VR Adoption Factors in Architecture: Developed vs. Developing Country Contexts *.

Factor	Developed Countries (e.g., US, UK)	Developing Countries (Oman, Malaysia)	Key Studies
Cost Barriers	Moderate (15–20% of firms cite as primary barrier)	High (45–60% of firms)	[3,4]
Technical Readiness	High (90% of firms have VR-compatible hardware)	Low (32–40% firms)	[2,5]
Training Availability	Widespread (70% of firms offer VR training)	Limited (25% firms)	[6,7]
BIM-VR Integration	Mature (85% integration success)	Emerging (35% success)	[2,8]
Client Demand	High (VR expected in 68% projects)	Low (12% projects)	[9,10]
Adoption Rate	62% of firms use VR routinely	18% of firms piloting VR	[3,11]
Primary Use Cases	- Design validation - Client presentations - Safety training	- Basic visualization - Education - Marketing	[12,13]
Key Enablers	- Standardized workflows - Vendor support	- Government incentives - University partnerships	[14–16]

* Note: The percentages are synthesized estimates from cited studies, and ranges reflect variations across studies due to differing samples and contexts.

Oman represents a strategically selected case study to address this gap, offering transferable insights into the readiness of young professionals in the Gulf Cooperation Council (GCC) and similar developing economies. Oman’s position is supported by regional indices; it holds a middle-rank in the GCC on the Network Readiness Index [17] and has aggressively invested in higher education, resulting in a high density of engineering graduates per capita [18]. The construction sector contributes approximately 9.1% to Oman’s GDP [19], aligning with other GCC economies, making it a pertinent case study for regional digital transformation challenges. Oman’s youthful architectural workforce demonstrates emerging technological readiness. This is characterized by moderate BIM penetration (35% vs. 85% in developed markets) and growing, yet uneven, VR access. This mirrors the broader challenges faced by developing countries [12]. Institutional dynamics like centralized decision-making and low client demand for VR (12% of projects) further reflect regional adoption barriers [9]. Oman’s Vision 2040 diversification agenda, which prioritizes construction sector modernization amid legacy system inertia, provides a microcosm to study digital transformation tensions common to emerging economies.

While previous studies have effectively mapped the landscape of BIM-VR adoption barriers [3,9,12], this study moves beyond identifying challenges to model the interplay of drivers that predict adoption intention among the next generation of architects. In this study, ‘VR readiness’ is operationalized not as current proficiency or widespread usage, but as the latent potential for future adoption. This potential is measured through behavioral intention following a structured first exposure, making it a necessary precursor to overcoming implementation barriers. Therefore, this research aims to provide valuable insights into the digital readiness of emerging professionals who will be at the forefront of the sector’s evolution. To analyze these dynamics, this study integrates the Unified

Theory of Acceptance and Use of Technology (UTAUT) with Presence Theory—a novel dual framework that bridges functional and experiential adoption drivers. While UTAUT explains functional factors like performance expectancy [14], Presence Theory captures immersion and emotional engagement critical for spatial design tasks [20]. Prior research has treated these dimensions in isolation, particularly in developing contexts where cultural norms and infrastructural asymmetries intersect. The study examines three hypotheses: (1) prior VR exposure enhances adoption intent; (2) perceived usefulness mediates this relationship; and (3) organizational support moderates technical barriers' impact. By testing this model in Oman's architectural sector—where traditional workflows coexist with digital aspirations—the research provides actionable insights for policymakers and firms navigating similar adoption challenges across the developing countries.

2. Literature Review

2.1. Virtual Reality in the Architecture, Engineering, and Construction (AEC) Industry

Virtual Reality (VR) has emerged as a transformative technology in the AEC sector, enabling immersive spatial visualization, enhanced stakeholder engagement, and more accurate design validation. In developed economies, VR is frequently integrated with Building Information Modeling (BIM) to support collaborative decision-making, reduce design errors, and streamline construction workflows [2]. Quantitative meta-analyses report that VR-enhanced workflows can reduce design-related revisions by up to 35% and improve stakeholder satisfaction by approximately 28% [4]. Beyond design visualization, VR has demonstrated significant impact in safety training and construction planning. Studies indicate that VR-based safety programs improve knowledge retention and hazard recognition by 30–40% over traditional training methods [11]. The broader implications for productivity and cost efficiency have made VR a strategic priority for digital transformation in high-income countries.

Despite these benefits, VR adoption in developing countries remains in its early stages. Infrastructural limitations, high capital investment, and organizational resistance are frequently cited as primary barriers [6]. Cross-national comparisons (Table 1) reveal systemic disparities in readiness, including gaps in technical infrastructure, digital literacy, and institutional support [3]. In developing countries, the moderate level of Building Information Modeling (BIM) integration, as evidenced by comparative adoption rates in Table 1, presents both a barrier to digital transformation and a strategic opportunity [2,12]. Within such contexts, virtual reality (VR) technology holds potential as a catalyst for accelerated BIM adoption [9,14]. VR generates tangible and visually compelling outputs from digital models, demonstrating a practical utility that traditional 2D representations lack. This enhanced capability boosts stakeholder engagement, helping to overcome resistance and build confidence in integrated digital workflows [14,19]. In addition to technological and economic barriers, human capital limitations (such as lack of exposure, inadequate training, and limited innovation culture) impede the diffusion of immersive technologies. Fragmented professional education and inconsistent policy support further restrict the scalability of VR applications [6].

Immersive technology adoption in GCC educational institutions is a critical precursor to sector-wide transformation, aligned with national visions like Oman Vision 2040 and Saudi Vision 2030. Region-specific studies show increasing use of VR/AR in architecture and engineering education for design studios, visualization, and safety training [7]. This pedagogical shift is cultivating a generation of graduates who expect to use immersive technology, enhancing future sector readiness [21]. Understanding this educational pipeline contextualizes the preparedness of the emerging professionals who are the focus of this study.

2.2. Theoretical Frameworks for Technology Adoption

Existing literature traditionally examines technological adoption through either a functional or experiential lens. From the functional perspective, the Unified Theory of Acceptance and Use of Technology (UTAUT) [14] has been widely applied to explain BIM and conventional technology adoption in the AEC sector. UTAUT emphasizes constructs like performance expectancy, effort expectancy, and social influence to predict user behavior. However, while UTAUT effectively captures functional drivers (e.g., perceived usefulness), it overlooks experiential dimensions such as immersion and emotional engagement, which are pivotal for immersive technologies like VR. Consequently, most UTAUT applications focus on conventional technologies or BIM adoption, with limited exploration of VR in resource-constrained settings [9].

Conversely, the experiential perspective, grounded in Presence Theory [20], highlights how affective responses—such as immersion, interface quality, and emotional engagement—shape user perceptions of VR [22]. Emerging research suggests that in early-exposure contexts, the emotional impact of VR experiences may outweigh functional value in driving adoption [23]. However, Presence Theory alone neglects organizational and behavioral drivers (e.g., social influence, institutional support), which are especially relevant in architectural workflows reliant on spatial cognition and client collaboration [10].

This divided theoretical approach creates a significant gap. It fails to adequately explain immersive technologies like VR, which derive their value from a dual foundation: utility and experience. This shortcoming becomes especially critical in developing countries, where infrastructural limitations and institutional resistance complicate adoption processes. In these environments, adoption choices cannot be fully explained by purely functional models like UTAUT, which emphasize rational decision-making, nor by purely experiential frameworks like Presence Theory, which focus on emotional engagement. Rather, these decisions emerge from a dynamic interaction between practical considerations and sensory engagement. For instance, an architect might be captivated by VR's immersive capabilities (experiential appeal) yet remain hesitant to adopt it without clear evidence of its seamless integration into existing workflows and strong organizational endorsement (functional and social drivers).

Thus, our integrated UTAUT-Presence Theory framework represents more than a combination of established models—it is a necessary synthesis addressing a specific theoretical inadequacy: the failure of single-perspective models to explain adoption in settings where technological, institutional, and cultural factors intersect. Within the proposed framework, 'readiness' is thus manifested through the key dependent variable of Behavioral Intention, which is the most proximal predictor of actual usage behavior [14]. By measuring intention after a controlled VR experience, we capture a snapshot of adoption potential, or 'readiness,' at a critical juncture: the point of discovery. By applying and validating this framework in Oman, this study moves beyond Western-centric adoption theories and offers a context-sensitive understanding of VR adoption.

2.3. Proposed Integrated Framework

Addressing gaps in prior literature, this study proposes an integrated framework combining functional and experiential dimensions to assess VR readiness among emerging architectural professionals in developing countries. Unlike conventional models that examine these domains separately [23], the proposed framework captures the interplay between technical utility, immersive experience, and socio-cultural factors—key influences in resource-constrained environments marked by infrastructural limitations and institutional inertia [3]. As detailed in Table 2, the framework operationalizes adoption through three interconnected domains: Perceived VR Experience, Perceived Technology Performance, and

Technology Adoption Perspective. By simultaneously addressing why architects adopt VR (functional utility) and how they experience it (immersion/emotion), while accounting for contextual constraints, this framework provides a more comprehensive lens for implementing immersive technologies in contexts where conventional models prove inadequate. The study hypotheses explicitly test these interrelationships, with particular attention to how organizational support mitigates technical barriers, a key differentiator from developed countries settings. To elaborate on this model, the following subsections provide detailed explanations of each domain.

Table 2. Proposed Integrated VR Adoption Framework: Domains, Criteria, and Hypotheses.

Domain	Criteria	Hypothesis	Theoretical Basis
Perceived VR Experience	Involvement Immersion Interface Quality Emotion	H1: Prior VR exposure positively correlates with adoption intention.	[20,22–24]
Perceived Technology Performance	Performance Expectancy Effort Expectancy Integration Training/Adaptability	H2: Perceived usefulness mediates the relationship between experience and adoption intention.	[3,14,15,25]
Technology Adoption Perspective	Attitudinal Orientation Social Influence Behavioral Intention	H3: Organizational support moderates the effect of technical barriers on adoption.	[9,14,15]

2.3.1. Perceived VR Experience

This domain evaluates the subjective quality of user interaction with VR environments through four key criteria rooted in Presence Theory [20], while maintaining conceptual links to UTAUT constructs. *Involvement* reflects the user’s perceived control and active participation in VR tasks [26], directly aligning with UTAUT’s effort expectancy through its impact on reducing perceived complexity and enhancing self-efficacy [14]. *Immersion* captures the depth of sensory engagement that simulates physical presence [24], indirectly supporting UTAUT’s performance expectancy by improving design validation accuracy [10]. *Interface Quality* measures the system’s intuitiveness [27], directly contributing to effort expectancy by minimizing cognitive load during interaction [25]. Finally, *Emotional Engagement* encompasses affective responses ranging from enjoyment to anxiety [22], which complement UTAUT’s social influence dimension by amplifying the effect of peer and managerial endorsements [28]. Together, these criteria bridge experiential and functional adoption drivers, particularly crucial in developing contexts where both technological familiarity and workflow integration pose challenges [3]. The inclusion of involvement specifically addresses architectural professionals’ need for active control in design processes, while its connection to effort expectancy provides a critical cross-theoretical link between Presence Theory and UTAUT frameworks.

2.3.2. Technology Performance

This domain draws on the Unified Theory of Acceptance and Use of Technology [14] to assess the functional drivers of VR adoption through four interconnected criteria. *Performance Expectancy* (Usefulness) represents the belief that VR will enhance task outcomes, serving as the cornerstone of adoption motivation and extensively validated in technology acceptance literature [25]. *Effort Expectancy* (Ease of Use) captures the perceived simplicity of system operation, particularly crucial in developing contexts where varying digital literacy levels may present adoption barriers [15]. *Integration* examines technology’s compatibility

with existing workflows and tools, where seamless interoperability reduces implementation friction and supports long-term utilization [29]. *Training Adaptability* addresses the critical need for flexible learning protocols in resource-constrained environments, serving as a compensatory mechanism for infrastructure limitations while ensuring effective skill transfer [4]. These criteria collectively operationalize the instrumental rationality behind technology adoption, with particular emphasis on architectural practice where workflow integration and practical utility often determine successful implementation [2]. The dimension maintains conceptual links to experiential factors through training's role in enhancing involvement and interface proficiency, thereby bridging functional and perceptual adoption drivers.

2.3.3. Technology Adoption Perspective

This domain examines VR adoption through a socio-cultural lens, incorporating three key criteria that interact with both experiential and functional factors. *Attitudinal Orientation* represents the cognitive evaluation of VR's value proposition, shaped by prior technology exposure and cultural openness to innovation, which mediates between perception and behavioral intention [30]. *Social Influence* reflects the impact of peer norms, managerial support, and institutional policies on individual adoption decisions, particularly powerful in collectivist professional cultures characteristic of many developing regions [28]. *Behavioral Intention* serves as the proximal determinant of actual system use, synthesizing attitudinal, normative, and controlling beliefs into actionable adoption readiness [15]. These criteria collectively address the organizational and cultural contexts that moderate technology assimilation, with relevance to architectural firms where hierarchical decision-making structures and client expectations significantly influence innovation adoption [9]. The domain's connection to experiential factors emerges through the emotional component of attitudes, while its relationship to functional aspects appears in the practical considerations underlying behavioral control perceptions. Together, they complete the integrated adoption framework by accounting for the social systems in which individual technology evaluations occur.

2.3.4. Conceptual Model and Hypotheses

Figure 1 illustrates the key hypothesized relationships between constructs in the proposed integrated VR adoption model. The framework proposes that adoption intention is shaped through three interconnected pathways: experiential, functional, and contextual. The *experiential pathway* links presence-related constructs to functional adoption drivers. Immersion is theorized to enhance performance expectancy by making VR's benefits more tangible for design validation tasks, while interface quality is expected to reduce cognitive load, thereby strengthening effort expectancy. Emotional engagement is hypothesized to amplify social influence through affective responses that shape workplace norms around technology use. The *functional pathway* connects technology performance factors to adoption intention. Performance expectancy and effort expectancy are positioned as central determinants of adoption intention, with their effects potentially moderated by the degree of system integration into existing workflows. Training adaptability is proposed as a compensatory mechanism that may offset infrastructure limitations in developing contexts.

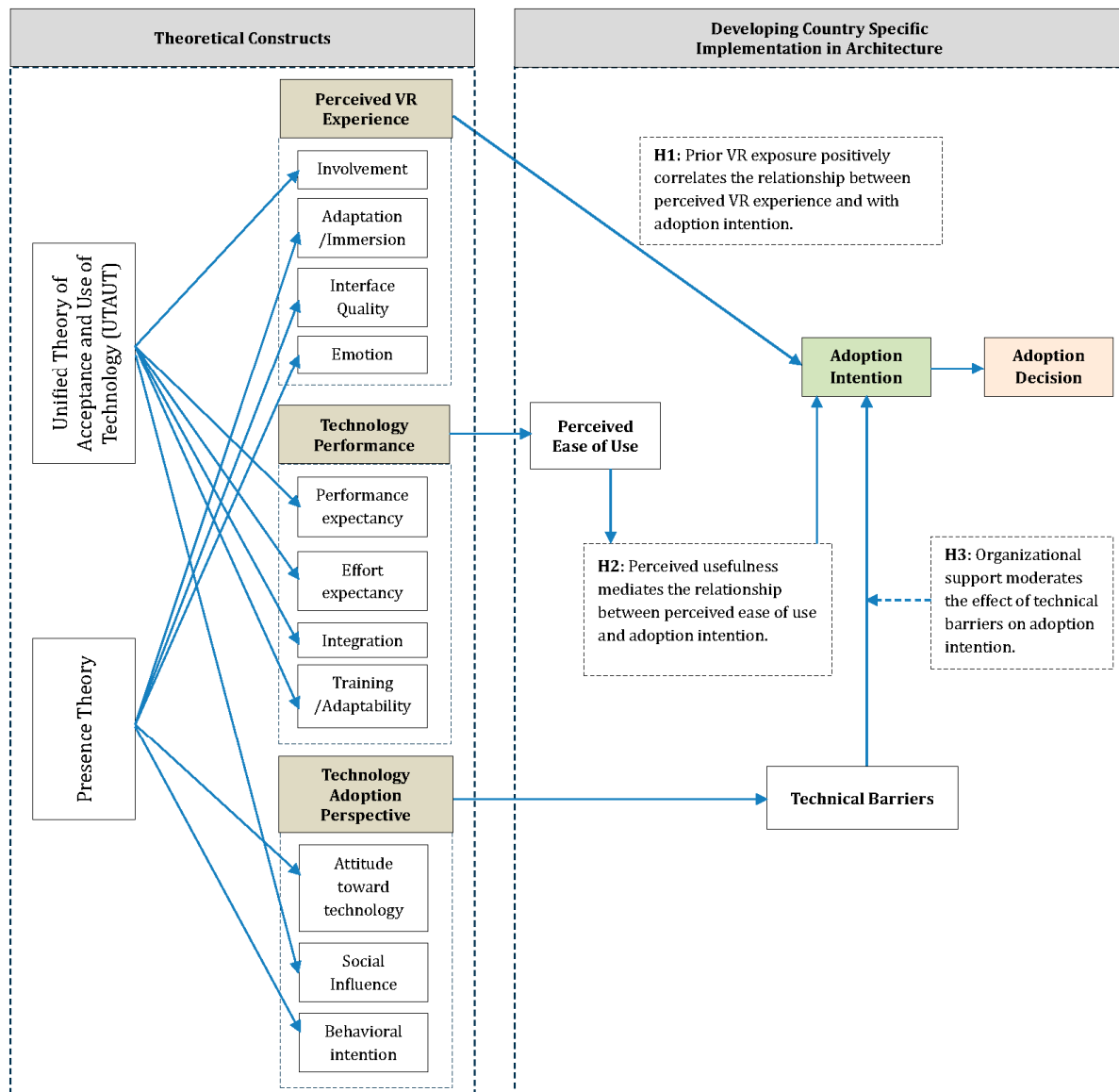


Figure 1. Integrated VR Adoption Framework combining UTAUT (functional) and Presence Theory (experiential) dimensions. *Note: Arrows denote hypothesized relationships, with dashed lines indicating moderation effects.*

The framework also specifies important *mediation pathways*, proposing that functional evaluations (particularly perceived usefulness and ease of use) may mediate the translation of experiential factors into adoption intention. Cross-dimensional effects are highlighted, such as how interface quality may influence both effort expectancy (functional) and involvement (experiential). These relationships are shown through directional arrows whose formatting denotes the nature of each hypothesized link (direct, mediated, or moderated).

3. Materials and Methods

The study adopted a quantitative research methodology, employing a post-exposure survey to evaluate factors influencing VR adoption intention among emerging architects in Oman. In this context, “adoption readiness” refers to the strength of this behavioral intention and the influence of its key drivers. The research was structured around two components: an immersive VR experience using industry-standard tools and a structured post-session questionnaire designed to capture multi-dimensional user responses.

A prototypical residential building was modeled using Autodesk Revit, reflecting a standard architectural typology familiar to the target demographic. To ensure immersive realism, the model was exported to Enscape, a real-time rendering and VR simulation platform. The simulation included various internal and external design alternatives to prompt evaluative responses. The model included multiple layout configurations for the living room and master bedroom, ceiling height variations, and facade treatment alternatives. This design diversity aimed to simulate real-world decision-making conditions and assess user interaction with complex architectural settings.

Participants were engaged through a series of structured group sessions. Each session followed a four-phase protocol:

1. **Orientation and Objective Setting (10–15 min):** Participants were welcomed and briefed on the objectives and format of the session, ensuring clarity on expected interactions and ethical participation.
2. **Technology Familiarization (5–10 min):** A demonstration and hands-on training segment was provided to acquaint users with VR headset controls and navigation features.
3. **Interactive VR Experience (30–40 min):** Participants explored the architectural scenarios, assessed design options, and engaged with spatial variables in real-time.
4. **Post-Experience Debrief and Survey (15 min):** A brief open discussion allowed participants to articulate initial impressions, followed by the administration of the structured questionnaire.

Sessions were conducted over a three-week period in mid-2024, with controlled participant group sizes to ensure sufficient facilitation and consistent exposure. A total of 61 responses were collected from participants with diverse roles in architecture, design, and construction in Oman. Respondents included architects (41%), interior designers (21%), construction engineers (18%), and academic professionals (20%). The sample included participants from both public (38%) and private (62%) sectors, ensuring diverse organizational representation. While the sample size ($N = 61$) may appear limited, it represents a significant proportion of the active junior to mid-level architectural professional community in Oman, a country with a concentrated AEC sector. The use of PLS-SEM is particularly recommended for such sample sizes in exploration research [31].

Survey Design

The survey instrument was developed based on a synthesis of validated constructs from established measurement models. The framework draws upon the Presence Questionnaire [26], the Achievement Emotions Questionnaire [22], the System Usability Scale [29], and the Unified Theory of Acceptance and Use of Technology [14].

The questionnaire was structured around three core domains (Table 3), each operationalized through multiple criteria and items:

1. *Perceived VR Experience:* Captures sensory and affective dimensions of the VR session, including control, immersion, interface responsiveness, and emotional reactions.
2. *Technology Performance:* Measures users' evaluations of the VR system's usefulness, ease of use, integration with architectural software, and required training effort.
3. *Technology Adoption Perspective:* Gauges psychological readiness and social influences, including individual attitudes toward VR, perceived organizational support, and behavioral intentions.

Table 3. Survey Questions.

Domain	Criteria	Sample Questions	Source
Perceived VR Experience	Involvement	How much were you able to control your experience?	[26]
	Immersion	How easily did you adapt to the control devices?	[20]
	Interface Quality	How much did interface limitations interfere with task completion? *	[26]
	Emotion	I felt confident/enjoyed the VR experience	[22]
Technology Performance	Performance Expectancy	VR improves productivity in my work	[14]
	Effort Expectancy	The system is easy to use	[25]
	Integration	VR tools work well with existing CAD software	[29]
	Training/Adaptability	Most people can learn VR quickly	[14]
Technology Adoption Perspective	Attitudinal Orientation	Using VR is beneficial to architecture	[14]
	Social Influence	My organization encourages VR use	[9]
	Behavioral Intention	I plan to use VR soon	[30]

* Reverse-coded item.

A five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree” was employed to measure responses. Data was analyzed using IBM SPSS software (version 29.0), applying descriptive statistics to identify trends and distributions. Inferential tests, including chi-square and Pearson correlation coefficients, were used to evaluate the relationship between prior VR exposure and adoption intention, as well as to examine subgroup differences.

4. Results and Discussion

4.1. Sample Characteristics

A total of 61 architecture professionals from Oman participated in the study (Table 4). The sample predominantly comprised female respondents (75.4%, $n = 46$), consistent with demographic trends reported in Oman’s built environment sector [8]. Age distribution skewed toward younger professionals, 85.2% of participants were aged 18–25 years, while the remaining 14.8% were aged 26–45 years, reflecting the “youth bulge” characteristic of developing economies in professional domains [32]. Only 21.3% of participants reported prior VR experience, aligning with infrastructural and resource constraints documented in emerging markets [2]. The sample size ($N = 61$) was deemed appropriate for the analytical method chosen. Following the guidelines for Partial Least Squares Structural Equation Modeling (PLS-SEM) by Hair et al. [31], the sample exceeds the requirement of being 10 times the largest number of structural paths pointing to a latent construct in the model. Furthermore, the sample represents a significant portion of the target population of emerging architectural professionals in Oman, a country with a concentrated AEC sector [8]. The demographic skew towards young, female professionals is representative of the recent graduation trends in Omani architectural higher education [19]. In fact, women constitute over 60% of engineering students in Oman [18]. Therefore, rather than a limitation, this sample provides crucial insights into the readiness of the next generation of architects at the forefront of the sector’s digital transformation. However, the sample underrepresents senior practitioners, which may limit the generalizability of the interpretation of subsequent findings.

Table 4. Participant Demographic Characteristics.

Variable	Category	Frequency	Percentage
Gender	Female	46	75.4%
	Male	15	24.6%
Age	18–25 years	52	85.2%
	26–45 years	9	14.8%
Professional Role	Architects	25	41.0%
	Interior Designers	13	21.3%
	Construction Engineers	11	18.0%
	Academics	12	19.7%
Prior VR Experience	Yes	14	22.9%
	No	47	77.1%

Given the model’s complexity (integrating UTAUT and Presence Theory constructs), Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed. This method was chosen for its suitability in handling small-to-medium sample sizes [31], its capacity to test hierarchical relationships, and its ability to assess mediation and moderation effects (as specified in Hypotheses 2 and 3) without requiring data normality. Moreover, PLS-SEM allows for the simultaneous evaluation of both the measurement and structural models. Data analysis was conducted in three phases: validation of the measurement model (including reliability, convergent validity, and discriminant validity), testing of the structural model (examining path coefficients, R^2 values, and effect sizes), and supplementary analyses, which included demographic comparisons using independent samples t-tests.

4.2. Validation of the Measurement Model

To assess the psychometric properties of the measurement scales, Cronbach’s alpha (α) was computed for each construct (Table 5). All scales demonstrated acceptable to excellent reliability ($\alpha \geq 0.71$), exceeding the threshold of 0.70 recommended for exploratory research [33]. The Technology Adoption Perspective scale exhibited the highest consistency ($\alpha = 0.83$), reflecting strong inter-item correlations among attitude, social influence, and behavioral intention measures, a pattern consistent with UTAUT validations in technology adoption studies [14]. Composite reliability (CR) ranged from 0.82 to 0.89; Average Variance Extracted (AVE) values exceeded 0.50, confirming convergent validity. Heterotrait-Monotrait (HTMT) ratios all fell below 0.85, supporting discriminant validity and ensuring distinctiveness among constructs within the integrated model [31].

Table 5. Reliability and Descriptive Statistics of Key framework Constructs.

Construct	Items	Mean Value	Standard Deviation (SD)	Cronbach’s Alpha (α)	Composite Reliability (CR)	Average Variance Extracted (AVE)	Heterotrait -Monotrait (HTMT) Full Matrix	VIF
Perceived VR Experience	4	4.12	0.89	0.71	0.82	0.53	0.68 (Tech. Perf) 0.59 (Tech. Adopt)	1.82
Technology Performance	4	4.25	0.76	0.73	0.85	0.58	0.73 (Tech. Adopt)	2.31
Technology Adoption	3	4.41	0.82	0.83	0.89	0.73	—	1.95

Notes: HTMT (Full Matrix): Values represent correlations between constructs. All values are below the 0.90 threshold, confirming discriminant validity. VIF: All Variance Inflation Factor values are below 5, indicating no multicollinearity issues.

4.3. Structural Model and Hypothesis Testing

The structural model was evaluated through bootstrapping with 5000 resamples to examine the proposed hypotheses relationships and assess the predictive validity of the

integrated theoretical framework. The structural model demonstrated strong explanatory power, accounting for 52% of variance in adoption intention ($R^2 = 0.52$) and 31% in perceived usefulness. Overall Standardized Root Mean Square Residual (SRMR: 0.063) and Normed Fit Index (NFI: 0.91) values confirmed good model fit, while Predictive Relevance (Q^2 values for perceived usefulness and adoption intention are 0.25–0.41, respectively) established predictive relevance. These metrics collectively validate the integrated UTAUT-Presence Theory framework's robustness in explaining VR adoption drivers.

Regarding hypothesis testing, the bootstrapping analysis (Table 6) revealed the following key findings:

Table 6. Summary of the structural model and hypothesis testing.

Hypothesis	Path	β	<i>p</i> -Value	95% CI	Result	f^2
H1: Prior VR Exposure → Adoption Intention	Direct effect	0.28	0.003	[0.10, 0.46]	Supported	0.15
Perceived Usefulness → Adoption Intention	UTAUT core relationship	0.53	<0.001 ***	[0.29, 0.77]	Supported	0.42
H2: Exposure → Perceived Usefulness → Adoption Intention	Indirect effect (mediation)	0.18	0.002 **	[0.09, 0.29]	Partial Mediation	-
H3: Barriers x Organizational Support → Adoption Intention	Interaction effect (moderation)	0.32	0.003 **	[0.11, 0.53]	Supported	0.12

Notes: Significance levels: ** $p < 0.01$, *** $p < 0.001$. All *p*-values are based on bootstrapped confidence intervals (5000 resamples). β = standardized path coefficient; CI = confidence interval; f^2 = effect size. Moderator Reliability: The moderator variables ("Technical Barriers" and "Organizational Support") showed good reliability: Technical Barriers: Cronbach's $\alpha = 0.76$, CR = 0.85, AVE = 0.59. Organizational Support: Cronbach's $\alpha = 0.82$, CR = 0.88, AVE = 0.65. Moderation Test Procedure: The interaction term was created using the product indicator approach (after mean-centering the predictors) and tested via PLS-SEM bootstrapping.

4.3.1. Prior VR Exposure and Adoption Intention (H1)

Supporting H1, prior VR exposure significantly predicted adoption intention ($\beta = 0.28$, $*p = 0.003$), aligning with Presence Theory's emphasis on experiential familiarity as a precursor to technology acceptance [20]. This effect was particularly strong among younger architects (<25 years: $\beta = 0.32$ vs. ≥ 26 years: $\beta = 0.18$), reinforcing generational divides in digital readiness [34]. However, the moderate effect size ($f^2 = 0.15$) suggests exposure alone is insufficient—a valuable indication for training programs in Oman and similar developing countries where VR access remains limited [2].

4.3.2. The Mediating Role of Perceived Usefulness (H2)

The relationship between prior exposure and adoption intention was partially explained by perceived usefulness. Statistically, perceived usefulness was a significant mediator (indirect $\beta = 0.18$, 95% CI [0.09, 0.29]), accounting for 39% of the total effect (VAF = 39%). This extends "Technology Acceptance Model" [25] by demonstrating that functional evaluations explain how exposure translates to intent—a mechanism previously untested in VR contexts. The strong direct effect of "Perceived usefulness" on "Adoption intention" ($\beta = 0.53$, $*p < 0.001$) underscores that architects prioritize functional benefits (e.g., design accuracy) over experiential ones, contrasting with consumer VR studies where immersion dominates [10]. This finding has direct practical implications: for VR to be adopted, its application must demonstrably improve core architectural tasks. This could be through enhanced client understanding in presentations, leading to faster approvals [16], or through more effective error detection in immersive design reviews, reducing costly rework during construction. This contrasts with consumer VR studies, where immersion dominates [23] and highlights the tool's professional value.

4.3.3. Moderation by Organizational Support (H3)

The results indicate that organizational support, conceptualized as a dimension of social influence, suggested a significant moderating role in the relationship between technical barriers and VR adoption intention (interaction $\beta = 0.32$, $p = 0.003$). Simple slope analysis revealed that among respondents in high-support environments (i.e., +1 SD), technical barriers exerted no statistically significant influence on adoption intention ($\beta = -0.08$, $p = 0.42$). Conversely, in contexts characterized by low organizational support (i.e., −1 SD), barriers substantially diminished adoption intention ($\beta = -0.49$, $p < 0.001$). The analysis indicates that organizational support plays a notable role in mitigating the influence of technical barriers on adoption intention. This relationship appears to be deeply rooted in the socio-cultural and organizational context of Oman and similar GCC economies, which are often characterized by high power distance and collectivism [28]. In such environments, employees may place significant trust in hierarchical authority and value collective goals. Consequently, visible endorsement from leadership can act as a strong legitimizing signal, potentially transforming the perception of VR adoption from an individual risk into a shared organizational objective. This top-down dynamic may be particularly effective in contexts like Oman's architectural sector, where centralized decision-making is common [9]. When leadership commits resources and policy support, it likely provides not only the tools for adoption but also fosters a sense of psychological safety, empowering professionals to engage with new technologies. Therefore, organizational support emerges as a key factor that can counteract technical barriers, a finding that contributes a valuable socio-cultural dimension to predominantly techno-economic models of technology adoption and underscores the importance of leadership in digital transformation initiatives within developing economies [35].

These findings collectively validate the integrated UTAUT-Presence Theory framework, demonstrating that both functional (performance expectations) and experiential (prior exposure) factors drive adoption, while highlighting the critical buffering role of organizational support in a developing economic context. The findings align with and refine the broader literature on technology adoption. Specifically, the result that organizational support is a critical moderator of technical barriers resonates with the work of Alam et al. [36], whose study in Malaysian higher education identified perceived organizational e-readiness (e.g., resources, training, support) as a more significant driver for VR adoption than external factors. This cross-sectoral consistency underscores the paramount importance of institutional enablers.

However, the Omani architectural context reveals a critical distinction. Its centralized, collectivist culture and high-power distance index [28] suggest that top-down endorsement may be an even more pivotal enabler than in other countries. This finding does not negate the significant role of technical barriers—such as interoperability challenges, hardware costs, and a steep learning curve, all reported by participants—but rather demonstrates that strong organizational support can effectively compensate for these impediments. Such support mitigates the social by-products of these barriers (e.g., frustration, reluctance) by providing necessary resources and policy mandates.

Furthermore, while studies like Noghabaei et al. [37] note that technological maturity broadly influences AEC adoption trends, the findings highlight that within environments of moderate technical readiness, subjective norms and institutional support can become decisive factors. This comparative perspective underscores that the pathways to adoption are highly context dependent. While the effect sizes observed are moderate, as is common in complex behavioral studies, they highlight influential relationships. The model's predictive relevance ($Q^2 = 0.25\text{--}0.41$) confirms its value for explaining VR adoption drivers in archi-

tectural practice, demonstrating that adoption is not contingent on a single factor but on a confluence of experiential, functional, and crucially, contextual and organizational drivers.

4.4. Demographic Comparisons

Independent samples t-tests were conducted to examine differences in adoption intention and perceived VR experience across key demographic groups (see Table 7). A statistically significant difference was observed in adoption intention based on prior VR exposure. Participants with prior VR experience reported significantly higher adoption intentions ($M = 4.68$, $SD = 0.71$) than those without such experience ($M = 4.12$, $SD = 0.85$), $t(59) = 3.21$, $p = 0.002$, Cohen's $d = 0.72$, indicating a large effect size. This finding supports the primary hypothesis (H1) and suggests that prior exposure to VR technology substantially increases users' intention to adopt it.

Table 7. Independent Samples t-Test Results for Hypothesis Testing.

Hypothesis	Comparison Groups	n	M (SD)	t(df)	p-Value	Cohen's d	95% CI	Interpretation
H1 Prior VR Exposure → Adoption Intention	With VR experience	14	4.68 (0.71)	3.21 (59)	0.002 **	0.72	[0.23, 0.89]	Significant difference, large effect
	No VR experience	47	4.12 (0.85)					
Age Differences → Adoption Intention	18–25 years	52	4.53 (0.79)	2.14 (59)	0.036 *	0.49	[0.03, 0.79]	Significant difference, medium effect
	26–45 years	9	4.12 (0.88)					
Gender Differences → Perceived VR Experience	Male	15	4.41 (0.82)	2.01 (59)	0.049 *	0.45	[0.002, 0.78]	Significant difference, medium effect
	Female	46	4.02 (0.91)					

Notes: Significance levels: * $p < 0.05$, ** $p < 0.01$. Cohen's d effect sizes: small ($|d| \geq 0.20$), medium ($|d| \geq 0.50$), large ($|d| \geq 0.80$). Independent samples t-tests assume equal variances (Levene's test $*p > 0.05$ for all comparisons). M = mean; SD = standard deviation; CI = confidence interval.

Exploratory analyses revealed additional demographic effects. Younger participants (18–25 years) demonstrated significantly higher adoption intention ($M = 4.53$, $SD = 0.79$) compared to those aged 26–45 years ($M = 4.12$, $SD = 0.88$), $t(59) = 2.14$, $p = 0.036$, $d = 0.49$, reflecting a medium effect. Gender differences were also identified in perceived VR experience, with male participants ($M = 4.41$, $SD = 0.82$) reporting significantly more positive experiences than females ($M = 4.02$, $SD = 0.91$), $t(59) = 2.01$, $p = 0.049$, $d = 0.45$, also representing a medium effect size. All comparisons satisfied the assumption of homogeneity of variances, as assessed by Levene's test ($p > 0.05$). The observed gender difference in perceived VR experience, with male participants reporting more positive experiences, warrants further investigation. This may be attributed to greater prior exposure to immersive technologies like video games among males, leading to higher initial self-efficacy [38]. Alternatively, it could relate to the design of the VR interface or the specific architectural scenarios used. This finding highlights the need for gender-inclusive design and training approaches in VR tool development and implementation strategies within the AEC sector.

5. Conclusions

In conclusion, this study moves beyond the application of isolated theories to offer a contextually grounded, integrated model for VR adoption. Its primary academic contribution lies in demonstrating that the interplay between experiential familiarity and functional utility is central to technology acceptance, and that this relationship is critically enabled by organizational context in developing economies. While the findings are necessarily constrained by the sample's demographic profile, primarily comprising students and junior professionals, this focus provides a valuable perspective on the sector's future. The emerging generation of architects—digital natives and future primary users—demonstrates that

their adoption intention is driven by a combination of direct experience, perceived utility, and, most importantly, the perceived support of their future organizations.

Therefore, this model elucidates the reasons why the subsequent generation of Omani architects is poised to embrace virtual reality, provided they enter supportive organizational environments. The findings suggest that for Oman and similar economies to realize their digital transformation goals, strategic efforts must target both the education of the emerging professionals and the cultivation of supportive organizational cultures within established firms.

The findings reveal three critical insights: First, perceived usefulness mediates 39% of exposure's impact on adoption, clarifying how immersive experiences translate to professional utility. Second, organizational support effectively counteracts technical barriers—a distinctive finding that challenges Western-centric cost-barrier perspectives and emphasizes the pivotal role of institutional enablers in developing economies. Third, while interface design showed limited effects on immersion, gender and age differences highlight the necessity for customized implementation approaches. These demographic patterns reveal meaningful sociocultural dynamics. The higher adoption intention among younger professionals aligns with Oman's "youth bulge" and indicates a generational receptiveness to digital tools among those with technology-oriented education [18]. Similarly, the more positive VR experiences reported by male participants may stem from earlier and more frequent exposure to immersive technologies, often shaped by gendered access to digital media [38]. Together, these insights highlight the role of sociotechnical backgrounds in shaping adoption attitudes and underscore the importance of implementation strategies that not only develop technical competencies but also bridge experiential divides to support inclusive digital transformation.

For VR training programs, the results suggest a need for structured, competency-based curricula that: (1) begin with foundational technical skills (hardware operation, basic navigation), (2) progress to discipline-specific applications (immersive design reviews, client presentation simulations), and (3) incorporate real-world workflow integration (BIM-VR interoperability training). Such programs should emphasize hands-on, scenario-based learning to simultaneously build technical proficiency and demonstrate functional utility—particularly important for overcoming initial skepticism among experienced professionals. Training modules could be delivered through hybrid formats combining in-person workshops for initial familiarization with ongoing virtual support for skill reinforcement.

Institutional adoption strategies should adopt a multi-tiered approach: At the organizational level, leadership must visibly champion VR initiatives through dedicated funding, policy mandates, and participation in demonstration projects. Mid-level implementation requires establishing internal VR champions—early adopters who can mentor colleagues and showcase successful use cases. At the operational level, institutions should develop standardized protocols for VR integration into existing workflows, including quality control procedures and performance metrics. Crucially, these strategies must be contextualized to local constraints, potentially starting with shared VR facilities before scaling to individual workstations.

By showing that institutional support can mitigate pervasive technical barriers, The study offers a meaningful theoretical refinement to conventional adoption literature and provides a replicable framework for future research in similar contexts. Practically, this shifts the focus from overcoming cost barriers to fostering supportive institutional cultures, a more actionable strategy for accelerating digital transformation in the GCC and similar regions. The results advocate for a phased adoption approach combining training (capitalizing on younger professionals' receptiveness), targeted utility demonstrations, and peer advocacy programs. The study particularly recommends: (1) creating VR competency

frameworks tied to career progression, (2) establishing cross-disciplinary user communities for knowledge sharing, and (3) developing localized content libraries showcasing regionally relevant case studies.

Findings of this study should be interpreted considering its limitations. Adoption drivers are constrained to the emerging generation of professionals within the Omani context and their initial exposure to VR. While the model offers a framework for understanding adoption in similar economies, generalizability to senior decision-makers or culturally distinct regions requires further validation. Although the sample size was sufficient for PLS-SEM, it constrains broader age-group analysis and hierarchical levels within the broader architectural sector of the GCC. Furthermore, the study measures behavioral intention rather than long-term use, and it lacks a precise measure for general digital literacy. Future longitudinal research should track actual use and incorporate a validated digital literacy scale.

Despite limitations in sample demographics and cultural scope, this research provides a validated model for technology adoption in resource-constrained professional contexts, offering theoretical depth through its hybrid framework and actionable guidance for policymakers and firms. To build on this foundation, future research should seek to integrate the perspectives of senior professionals and decision-makers to allow comparative analysis and build a complete, multi-generational model of technology adoption within the sector. Additionally, as this study measures behavioral intention rather than long-term actual use, future longitudinal research is needed to track actual usage behavior and long-term implementation success. Furthermore, future studies should expand into diverse cultural settings while incorporating longitudinal behavioral data and economic impact assessments to strengthen both theoretical and practical contributions to the field of immersive technology adoption.

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Institutional Review Board Statement: Under Article (3)(i) of the Personal Data Protection Law promulgated by Royal Decree 6/2022, “the provisions of this Law shall not apply to the processing of personal data . . . for the purposes of historical, statistical, scientific, literary, or economic research conducted by entities authorised to perform such works, provided that any indication or reference relating to the personal data subject shall not be used in published research or statistics to ensure that personal data is not attributed to an identified or identifiable natural person”. <https://www.mtcit.gov.om/ITAPortal/Data/English/DocLibrary/2024115132533256/PROMULGAT-ING%20THE%20PERSONAL%20DATA%20PROTECTION%20LAW.pdf> As our survey data is fully anonymized, cannot be attributed to identifiable individuals, and falls under the category of scientific research with minimal risk, the study is exempt from the requirement for prior approval by an ethics committee under Omani law.

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References

- Wang, X.; Truijens, M.; Hou, L.; Wang, Y.; Zhou, Y. Integrating Augmented Reality with Building Information Modeling: Onsite construction process controlling for liquefied natural gas industry. *Autom. Constr.* **2014**, *40*, 96–105. [CrossRef]
- El Hajj, C.; Montes, G.M.; Jawad, D. An overview of BIM adoption barriers in the Middle East and North Africa developing countries. *Eng. Constr. Archit. Manag.* **2023**, *30*, 889–913. [CrossRef]
- Algassim, H.; Sepasgozar, S.M.E.; Ostwald, M.J.; Davis, S. Developing a Novel Architectural Technology Adoption Model Incorporating Organizational Factors and Client Satisfaction. *Buildings* **2025**, *15*, 1668. [CrossRef]
- Mohamed, A.G.; Alqahtani, F.K.; Ismail, E.R.; Nabawy, M. Synergizing BIM and Value Engineering in the Construction of Residential Projects: A Novel Integration Framework. *Buildings* **2024**, *14*, 2515. [CrossRef]
- Hong, J.; Akotia, J.; Egbu, C. Virtual Reality in Construction Activities: Barriers for Adoption in China. *Constr. Econ. Build.* **2024**, *24*, 77–93. [CrossRef]
- Shu, C.; Srimuang, K. A dynamic capability perspective on digital transformation: Drivers, the process and consequences. *Manag. Decis.* **2025**, *ahead-of-print*. [CrossRef]
- Ummihusna, A.; Zairul, M. Investigating immersive learning technology intervention in architecture education: A systematic literature review. *J. Appl. Res. High. Educ.* **2022**, *14*, 264–281. [CrossRef]
- Alkalbani, S.; Rezgui, Y.; Vorakulpipat, C.; Wilson, I.E. ICT adoption and diffusion in the construction industry of a developing economy: The case of the sultanate of Oman. *Archit. Eng. Des. Manag.* **2012**, *9*, 62–75. [CrossRef]
- Gerges, M.; Austin, S.; Mayouf, M.; Ahiakwo, O.; Jaeger, M.; Saad, A.; El Gohary, T. An Investigation into the Implementation of Building Information Modeling in the Middle East. *J. Inf. Technol. Constr.* **2017**, *22*, 1–15. Available online: <https://www.itcon.org/paper/2017/1> (accessed on 1 May 2025).
- Portman, M.E.; Natapov, A.; Gewirtzman, D.F. To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning. *Comput. Environ. Urban Syst.* **2015**, *54*, 376–384. [CrossRef]
- Adami, P.; Rodrigues, P.B.; Woods, P.J.; Gerber, B.B.; Soibelman, L.; Gencturk, Y.C.; Lucas, G. Effectiveness of VR-based training on improving construction workers' knowledge, skills, and safety behavior in robotic teleoperation. *Adv. Eng. Inform.* **2021**, *50*, 101431. [CrossRef]
- Al Aamri, A.M.S.; Evdorides, H.; Baniotopoulos, C. Barriers and Opportunities for the Adoption of Building Information Modelling in the Design of Buildings: Case Study of Oman. *Sustainability* **2025**, *17*, 3510. [CrossRef]
- Waly, A.F.; Thabet, W.Y. A Virtual Construction Environment for preconstruction planning. *Autom. Constr.* **2003**, *12*, 139–154. [CrossRef]
- Venkatesh, V.; Thong, J.Y.; Xu, X. Unified Theory of Acceptance and Use of Technology: A Synthesis and the Road Ahead. *J. Assoc. Inf. Syst.* **2016**, *17*, 328–376. [CrossRef]
- Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D. User Acceptance of Information Technology: Toward a Unified View. *MIS Q.* **2003**, *27*, 425–478. [CrossRef]
- Zaker, R.; Coloma, E. Virtual reality-integrated workflow in BIM-enabled projects collaboration and design review: A case study. *Vis. Eng.* **2018**, *6*, 4. [CrossRef]
- Portulans Institute. Network Readiness Index 2024. 2024. Available online: <https://download.networkreadinessindex.org/reports/data/2024/nri-2024.pdf> (accessed on 1 May 2025).
- UNESCO. *UNESCO Science Report: The Race Against Time for Smarter Development*; UNESCO Publishing: Paris, France, 2021; pp. 437–442. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000235406> (accessed on 1 May 2025).
- National Centre for Statistics and Information (NCSI). *Statistical Yearbook: Issue 51–September 2023*; Sultanate of Oman: Muscat, Oman, 2023. Available online: https://www.ncsi.gov.om/Elibrary/LibraryContentDoc/bar_Statistical%20Year%20Book%202023%20Issue%2051_937cfd51-85c8-49b2-b61b-0e66af8afb4b.pdf (accessed on 1 May 2025).
- Slater, M.; Wilbur, S. A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments. *Presence Teleoperators Virtual Environ.* **1997**, *6*, 603–616. [CrossRef]
- Kandil, A.; Moussa, R. Impact of virtual reality on interior design project assessment: A comparative study at the University of Buraimi, Oman. In *Harmony in Architectural Science and Design: Sustaining the Future, Proceedings of the 57th International Conference of the Architectural Science Association, Gold Coast, Australia, 26–29 November 2024*; Zhang, F., Yu, R., Bischeri, C., Liu, T., Khoshbakht, M., Eds.; Griffith University: Gold Coast, Australia, 2024; pp. 678–685. Available online: https://archscience.org/wp-content/uploads/2025/03/Impact-of-virtual-reality-on-interior-design-project-assessment_A-comparative-study-at-the-University-of-Buraimi-Oman.pdf (accessed on 1 May 2025).
- Pekrun, R.; Goetz, T.; Frenzel, A.C.; Barchfeld, P.; Perry, R.P. Measuring emotions in students' learning and performance: The Achievement Emotions Questionnaire (AEQ). *Contemp. Educ. Psychol.* **2011**, *36*, 36–48. [CrossRef]
- Sagnier, C.; Loup-Escande, E.; Lourdeaux, D.; Thouvenin, I.; Valléry, G. User Acceptance of Virtual Reality: An Extended Technology Acceptance Model. *Int. J. Hum.-Comput. Interact.* **2020**, *36*, 993–1007. [CrossRef]
- Slater, M. Immersion and the illusion of presence in virtual reality. *Br. J. Psychol.* **2018**, *109*, 431–433. [CrossRef]

25. Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* **1989**, *13*, 319–340. [[CrossRef](#)]
26. Witmer, B.G.; Singer, M.J. Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence* **1998**, *7*, 225–240. [[CrossRef](#)]
27. Voinescu, A.; Petrini, K.; Fraser, D.S. Presence and simulator sickness predict the usability of a virtual reality attention task. *Virtual Real.* **2023**, *27*, 1967–1983. [[CrossRef](#)]
28. Hofstede, G.H. *Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations*, 2nd ed.; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2001.
29. Brooke, J. SUS: A 'Quick Disrty' Usability Scale. In *Usability Evaluation in Industry*, 1st ed.; Jordan, P.W., Thomas, B., McClelland, I.L., Weerdmeester, B., Eds.; CRC Press: Boca Raton, FL, USA, 1996; pp. 189–194. [[CrossRef](#)]
30. Ajzen, I. The Theory of Planned Behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [[CrossRef](#)]
31. Hair, J.F.; Hult, G.T.; Ringle, C.M.; Sarstedt, M. *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 3rd ed.; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2022.
32. United Nations Development Programme (UNDP); UNDP Regional Bureau for Arab States. Arab Human Development Report 2022: Expanding Opportunities for an Inclusive and Resilient Recovery in the Post-Covid Era. 2022. Available online: <https://www.undp.org/arab-states/publications/arab-human-development-report-2022-expanding-opportunities-inclusive-and-resilient-recovery-post-covid-era> (accessed on 1 May 2025).
33. Taber, K.S. The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Res. Sci. Educ.* **2018**, *48*, 1273–1296. [[CrossRef](#)]
34. Prensky, M. Digital Natives, Digital Immigrants. *Horizon* **2001**, *9*, 1–6. [[CrossRef](#)]
35. Maqsoom, A.; Zulfarnain, M.; Irfan, M.; Ullah, F.; Alqahtani, F.K.; Khan, K.I. Drivers of, and Barriers to, the Adoption of Mixed Reality in the Construction Industry of Developing Countries. *Buildings* **2023**, *13*, 872. [[CrossRef](#)]
36. Alam, S.S.; Ahmed, S.; Kokash, H.A. Interplay of perceived organizational and external e-readiness in the adoption and integration of augmented reality and virtual reality technologies in Malaysian higher education institutions. *Educ. Inf. Technol.* **2024**, *29*, 13735–13761. [[CrossRef](#)]
37. Noghabaei, M.; Heydarian, A.; Balali, V.; Han, K. Trend Analysis on Adoption of Virtual and Augmented Reality in the Architecture, Engineering, and Construction Industry. *Data* **2020**, *5*, 26. [[CrossRef](#)]
38. Quaiser-Pohl, C.; Geiser, C.; Lehmann, W. The relationship between computer-game preference, gender, and mental-rotation ability. *Personal. Individ. Differ.* **2006**, *40*, 609–619. [[CrossRef](#)]

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