



(RESEARCH ARTICLE)



## From representation to immersion: Transforming architectural design evaluation through virtual reality in a south African design studio

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### Abstract

Architectural design evaluation has traditionally relied on two-dimensional (2D) drawings and static representations, which often limit the depth and accuracy of critique processes. This study reconceptualises design evaluation by investigating the role of Virtual Reality (VR) as an immersive medium for critique, feedback, and spatial understanding within architectural education.

The research was conducted at Nelson Mandela University (NMU), involving 30 postgraduate architecture students and 15 academic staff members within the Faculty of Engineering, the Built Environment and Technology (EBET). A mixed-methods approach was employed, where students participated in a VR-based design activity, and staff engaged in both traditional 2D critique sessions and immersive VR-based evaluations.

The findings reveal that VR significantly enhances design evaluation, enabling both students and staff to engage more deeply with architectural proposals. Students reported improved ability to identify design strengths and weaknesses, while staff indicated that immersive environments allowed them to become “submerged” within student work, leading to more precise, context-aware, and meaningful feedback. Comparative analysis between 2D and 3D/4D evaluation demonstrates that immersive critique environments improve spatial interpretation, reduce miscommunication, and support higher-order thinking processes.

However, challenges related to training, technological access, and institutional readiness remain. The study concludes that VR has the potential to transform architectural critique from a representational exercise into an experiential and interactive process, fundamentally reshaping how design is evaluated in studio-based learning.

**Keywords:** Virtual Reality; Architectural Education; Immersive Learning; Design Studio; Spatial Cognition; Higher Education

### 1. Introduction

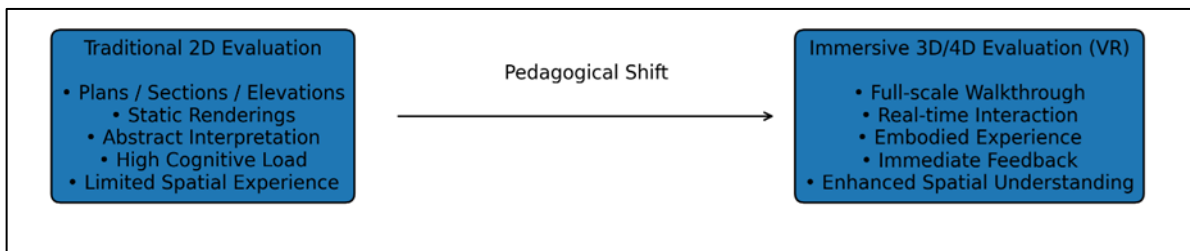
Design evaluation and critique are central to architectural education, forming the foundation through which students develop critical design thinking, spatial reasoning, and professional communication skills. Within the architectural studio, critique sessions function as key pedagogical moments where ideas are interrogated, refined, and validated through dialogue between students and lecturers. These interactions are essential for cultivating higher-order thinking skills such as analysis, evaluation, and synthesis, which are fundamental to both academic development and professional practice [3] [5].

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Traditionally, architectural critique relies on two-dimensional (2D) representational tools, including plans, sections, elevations, and rendered visualisations, often supplemented by physical models. While these methods remain integral to architectural pedagogy, they require both students and educators to cognitively reconstruct three-dimensional spatial conditions from abstract representations. This process imposes a significant cognitive load and can lead to fragmented or incomplete spatial understanding, particularly for complex or multi-layered design proposals [7] [2].

A critical limitation of this representational approach is the inherent disconnect between design intention and spatial experience. The translation of three-dimensional space into two-dimensional drawings often results in misinterpretation of scale, proportion, circulation, and user experience. Consequently, critique sessions may disproportionately focus on the quality of representation such as graphical clarity or visual aesthetics, rather than on the actual spatial performance and experiential qualities of the design [6] [10]. This limitation constrains the depth and effectiveness of feedback, potentially hindering the development of students' evaluative and reflective design capabilities.

The emergence of Virtual Reality (VR) introduces a significant paradigm shift in architectural education from representational evaluation (2D) to immersive evaluation (3D/4D). This shift, illustrated in Figure 1, redefines the way architectural designs are experienced, interpreted, and critiqued. VR enables users to enter and navigate architectural environments at full scale, facilitating real-time interaction and embodied spatial engagement. Unlike traditional methods, immersive environments allow both students and lecturers to experience architecture as a lived condition rather than as an abstract construct [3] [7].



**Figure 1** Paradigm Shift from Representational (2D) to Immersive (3D/4D) Design Evaluation

Importantly, this transition extends beyond three-dimensional visualisation to what can be conceptualised as four-dimensional (4D) evaluation, where spatial experience is integrated with time, movement, and user interaction. In this context, architectural evaluation becomes dynamic and experiential, allowing for the assessment of sequences, transitions, and occupation patterns within a design. Such immersive engagement aligns with constructivist and experiential learning theories, which emphasise knowledge construction through active participation and embodied interaction [9] [11].

Within the critique environment, VR fundamentally transforms the role of both students and lecturers. Students are no longer required to imagine spatial conditions but can directly experience and evaluate them, leading to improved identification of design strengths and weaknesses. Simultaneously, lecturers are able to move beyond external observation and become immersed within the student's design, enabling more precise, context-aware, and experientially grounded feedback. This shift has significant implications for the quality, depth, and effectiveness of architectural critique [5] [6].

Despite these advantages, the integration of VR into architectural education remains uneven, particularly within resource-constrained contexts such as South Africa. Challenges related to technological access, training, and institutional readiness continue to limit the widespread adoption of immersive tools in studio-based learning environments [4] [8]. These contextual constraints highlight the need for empirical, institution-specific research that examines not only the benefits of VR but also its practical implementation within real educational settings.

Against this backdrop, this study investigates how VR transforms architectural design evaluation and critique within the School of Architecture at Nelson Mandela University (NMU). Specifically, the research examines three key dimensions:

- The transformation of design evaluation processes from abstract to experiential
- The enhancement of critique quality and feedback depth

- The evolving role of lecturers as immersive participants within student work

By focusing exclusively on NMU postgraduate students and academic staff, the study provides a contextually grounded analysis that contributes to the broader discourse on immersive learning while addressing a critical gap in Global South architectural education research. Ultimately, the study positions VR not merely as a technological enhancement, but as a pedagogical instrument capable of redefining how architectural design is evaluated, experienced, and communicated.

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## **2. Conceptual Shift: 2D vs 3D/4D Evaluation**

A central contribution of this study lies in articulating a conceptual shift in architectural pedagogy from traditional representational evaluation (2D) toward immersive and experiential evaluation (3D/4D). This shift is not merely technological, but epistemological, as it fundamentally redefines how architectural knowledge is constructed, interpreted, and assessed within the design studio.

### **2.1. Traditional Evaluation (2D): Representation-Based Critique**

Architectural evaluation has historically been grounded in two-dimensional (2D) representational media, including plans, sections, elevations, and static renderings. These tools serve as abstractions of spatial conditions, requiring both students and lecturers to mentally reconstruct three-dimensional environments from symbolic representations. While this approach has long been embedded in architectural pedagogy, it introduces several inherent limitations.

Firstly, 2D representations rely heavily on indirect spatial interpretation, which demands advanced cognitive translation skills. Students must mentally simulate depth, scale, and spatial relationships, often resulting in fragmented or incomplete understanding, particularly in early stages of design development [7] [2]. This process increases cognitive load, as learners are required to simultaneously decode visual information and construct spatial meaning.

Secondly, traditional evaluation methods tend to privilege representation over experience. Critiques often focus on graphical clarity, composition, and presentation quality, rather than on how the design performs spatially or experientially. As a result, key aspects such as circulation, human scale, and user interaction may be overlooked or misinterpreted [6] [10].

Thirdly, the static nature of 2D drawings limits the ability to evaluate architecture as a temporal and dynamic phenomenon. Architecture is inherently experienced through movement, sequence, and occupation, yet traditional tools offer only fixed viewpoints, restricting the ability to assess transitions between spaces or the progression of user experience [3].

### **2.2. Immersive Evaluation (3D/4D): Experience-Based Critique**

In contrast, immersive technologies such as Virtual Reality (VR) enable a shift toward experience-based evaluation, where architectural space is no longer inferred but directly encountered. Within a 3D immersive environment, users can navigate, explore, and interact with design proposals at full scale, allowing for immediate and intuitive spatial understanding.

This immersive approach supports embodied interaction, where learning and evaluation are grounded in sensory and physical engagement with the environment. According to embodied cognition theory, knowledge is constructed through interaction between the body and space, making immersive environments particularly effective for spatial learning and evaluation [3] [5].

Furthermore, VR introduces the dimension of real-time navigation, enabling users to move through space dynamically rather than viewing it from fixed perspectives. This allows for the evaluation of spatial relationships, visibility, circulation patterns, and functional performance in ways that are not possible through static representations [6].

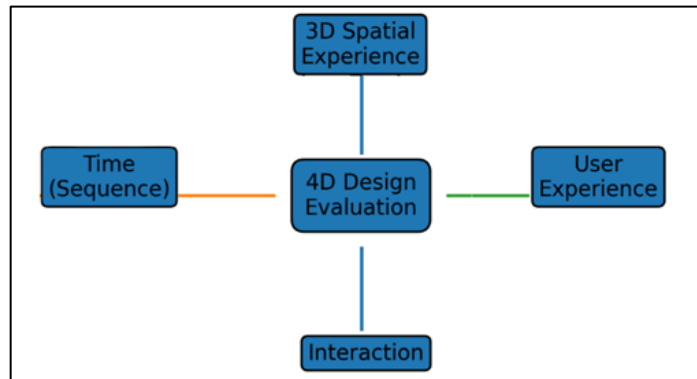
Immersive environments integrate time-based experience, allowing users to perceive architecture as a sequence of events rather than as isolated views. This temporal dimension is essential for understanding how spaces are used, experienced, and inhabited over time, aligning architectural evaluation more closely with real-world conditions [7].

### **2.3. Towards 4D Design Evaluation**

Building on these distinctions, this study introduces the concept of 4D Design Evaluation, which extends beyond three-dimensional visualisation to incorporate time, user experience, and interaction as integral components of architectural assessment.

This framework is conceptualised as: 3D Space + Time + User Experience + Interaction

The conceptual structure of this model is presented in Figure 2.



**Figure 2** 4D Design Evaluation Framework for Immersive Architectural Critique

Within this framework, architectural evaluation is reconceptualised as a multi-dimensional and experiential process, where:

- 3D Space enables full-scale spatial perception and understanding
- Time captures movement, sequence, and transitions through space
- User Experience reflects how individuals perceive, occupy, and engage with environments
- Interaction allows real-time manipulation, feedback, and iterative exploration

Together, these dimensions transform architectural critique from a static review of representations into a dynamic, immersive, and user-centred evaluation process.

Importantly, this model aligns with constructivist and experiential learning theories, which emphasise that knowledge is actively constructed through experience, reflection, and interaction [9] [11]. By enabling students and lecturers to engage directly with architectural space, 4D evaluation supports deeper cognitive processing and higher-order thinking, particularly in relation to analysis, evaluation, and design refinement [5].

#### 2.4. Implications for Architectural Critique

The shift toward 4D evaluation has significant implications for the nature of architectural critique. In this model, design is no longer evaluated as a static object but as a lived, navigable, and experiential environment. This fundamentally alters:

- How design is understood (from abstract to experiential)
- How feedback is generated (from general to context-specific)
- How students engage with critique (from passive reception to active exploration)

Moreover, this shift enables lecturers to move beyond external observation and become immersed participants within the design, enhancing their ability to provide precise, spatially grounded feedback. This redefines the critique process as a shared experiential dialogue, rather than a one-directional evaluation [5].

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### 3. Design/Methodology/Approach

#### 3.1. Research Design

This study adopts a mixed-methods research design, integrating quantitative and qualitative approaches to provide a comprehensive evaluation of how Virtual Reality (VR) transforms architectural design evaluation and critique processes. Mixed-methods research is particularly appropriate in educational contexts, as it enables the triangulation of measurable outcomes with experiential insights, thereby enhancing the validity and interpretive depth of findings [1].

The study is grounded in a constructivist–pragmatic paradigm, which assumes that knowledge is actively constructed through interaction, experience, and reflection within authentic learning environments [9] [11]. Within this framework, VR is positioned not merely as a technological tool, but as a pedagogical medium that enables experiential engagement, embodied cognition, and higher-order thinking in architectural design [3].

A within-subject comparative design was employed, whereby the same architectural project was evaluated using both traditional 2D methods and immersive VR environments. This approach ensures internal consistency and allows for direct comparison between representational and experiential modes of evaluation, which is essential for isolating the pedagogical impact of VR [7].

### 3.2. Participants

The study involved a purposive sample of 45 participants from the Faculty of Engineering, the Built Environment and Technology (EBET) at Nelson Mandela University (NMU), comprising:

- 30 postgraduate architecture students
  - 15 Honours students
  - 15 Master’s students
- 15 academic staff members involved in design studio teaching and critique

Purposive sampling was selected to ensure that participants possessed the necessary disciplinary knowledge and design experience to meaningfully engage in both traditional and immersive evaluation processes. This sampling strategy is widely adopted in educational research where the aim is to generate context-specific, in-depth insights rather than statistical generalisation [1].

The inclusion of both students and academic staff represents a key strength of the study, as it enables the examination of design evaluation from both learner and educator perspectives, which is often underrepresented in immersive learning research [5].

### 3.3. Study Procedure

The research was conducted through a structured, multi-stage process designed to compare traditional and immersive modes of design evaluation. The procedure consisted of the following steps:

- Step 1: Design Task (Student Production Phase): Students were required to design a small residential unit (5m × 10m), a task selected for its balance between manageable scale and sufficient spatial complexity. This project required students to engage with key architectural considerations, including spatial organisation, circulation, and user experience.
- Step 2: Traditional Critique (2D Evaluation): Students presented their designs using conventional representational tools, including plans, sections, elevations, and digital renderings. Academic staff conducted critique sessions based on these materials, providing feedback grounded in abstract spatial interpretation. This stage reflects standard studio practice and serves as the baseline condition for comparison [6].
- Step 3: VR Immersive Walkthrough (3D/4D Evaluation): Students then imported their designs into a VR environment and engaged in immersive walkthroughs using headset-based interaction. This enabled both students and staff to experience the design at full scale, allowing for real-time navigation, spatial exploration, and interaction. Immersive environments have been shown to significantly enhance spatial cognition and experiential learning by enabling direct engagement with architectural space [3] [7].
- Step 4: Staff Re-evaluation in VR: Academic staff re-evaluated the same student projects within the VR environment. This stage is critical, as it allows for a direct comparison between 2D-based critique and immersive evaluation, highlighting differences in feedback quality, spatial interpretation, and evaluative depth.
- Step 5: Comparative Feedback Collection
  - Data were collected through:
    - Structured questionnaires (Likert-scale responses)
    - Observational notes during critique sessions
    - Reflective feedback from both students and staff

This multi-source data collection supports methodological triangulation, enhancing the reliability and validity of findings [1].

### 3.4. Key Comparative Framework: 2D vs VR Evaluation

The central methodological contribution of this study lies in its direct comparison of evaluation modes, whereby the same architectural project is assessed under two distinct conditions: Traditional 2D Evaluation vs Immersive VR Evaluation.

This within-subject comparison eliminates variability associated with different design outputs, ensuring that observed differences in evaluation are attributable to the mode of representation and interaction, rather than to differences in design quality.

This approach enables the study to systematically examine how immersive environments influence:

- Design evaluation accuracy
- Critique depth and specificity
- Spatial understanding and interpretation
- Lecturer engagement and immersion

Such comparative designs are particularly valuable in immersive learning research, as they allow for the isolation of the unique affordances of VR, including real-time interaction, embodied experience, and spatial immersion [5] [10].

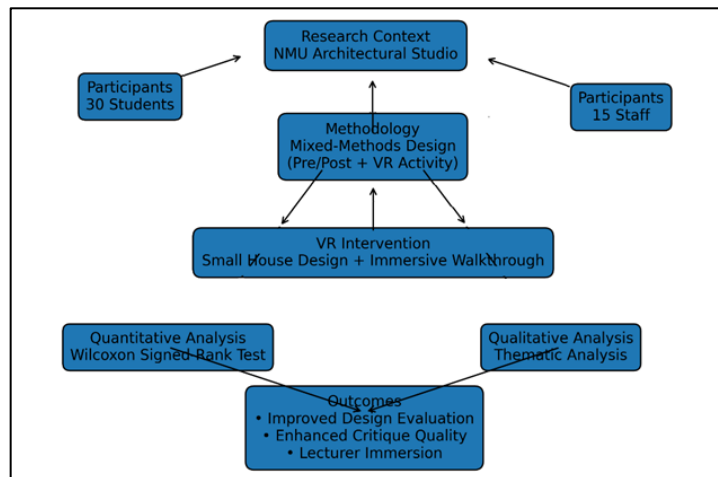
### 3.5. Data Analysis

Quantitative data derived from Likert-scale questionnaires were analysed using descriptive statistics and the Wilcoxon signed-rank test, a non-parametric statistical method suitable for paired, ordinal data and small sample sizes [13]. This test was used to determine whether differences between 2D and VR evaluations were statistically significant.

Qualitative data from observations and reflections were analysed using thematic analysis, enabling the identification of recurring patterns related to critique quality, spatial understanding, and user experience. Thematic analysis is widely used in educational research for interpreting participants' lived experiences and perceptions [12].

The integration of quantitative and qualitative findings provides a comprehensive understanding of how VR transforms architectural design evaluation, supporting both statistical validation and experiential interpretation.

The overall research design and analytical framework of the study are summarised in Figure 5 below.



**Figure 3** Research Design and Methodological Framework

## 4. Findings/Results

### 4.1. Improved Design Evaluation

The findings indicate a substantial improvement in students' ability to evaluate architectural design when engaging with immersive Virtual Reality (VR) environments compared to traditional two-dimensional (2D) representations.

Quantitative results (Table 1) demonstrate significantly higher mean scores across all evaluation-related dimensions in the VR condition, while qualitative observations further support these findings.

Students reported that VR enabled them to identify more design flaws and inconsistencies than during 2D-based critique sessions. This included improved detection of issues related to spatial proportions, circulation inefficiencies, and functional relationships between spaces. In contrast, traditional evaluation methods often required students to infer these conditions abstractly, leading to partial or delayed recognition of design shortcomings.

Specifically, students demonstrated an increased ability to:

- Evaluate scale and proportion within a full-scale immersive environment
- Assess circulation patterns and movement sequences through real-time navigation
- Understand spatial relationships and adjacencies more intuitively

These findings suggest that VR reduces the cognitive burden associated with translating 2D representations into 3D mental models, thereby enabling more direct and accurate spatial interpretation [7] [2]. This aligns with research indicating that immersive environments enhance spatial cognition by allowing users to engage directly with architectural space rather than reconstructing it mentally [3].

Importantly, the shift observed in this study can be summarised as a transition from: “Guessing space” (2D interpretation) → “Experiencing space” (VR immersion).

This transition represents a fundamental pedagogical shift, where evaluation becomes grounded in embodied and experiential understanding, supporting deeper cognitive engagement and higher-order thinking processes [5].

#### **4.2. Enhanced Critique Quality**

A key finding of this study is the significant improvement in the quality, depth, and precision of critique feedback provided by academic staff when using VR-based evaluation compared to traditional methods.

Staff reported that immersive environments enabled them to deliver more specific, context-aware, and spatially accurate feedback, particularly in relation to:

- Proportional relationships between spaces
- Spatial flow and user movement
- Experiential qualities of the design

In traditional critique settings, feedback is often based on interpretation of drawings, which may lead to generalised or speculative comments. In contrast, VR allows lecturers to directly experience the design at human scale, enabling immediate identification of spatial issues and more precise articulation of feedback.

This enhancement in critique quality is consistent with existing literature, which highlights the role of immersive technologies in improving communication and reducing ambiguity in architectural design evaluation [6] [10]. By providing a shared experiential environment, VR facilitates clearer dialogue between students and lecturers, strengthening the critique process.

A representative participant statement illustrates this shift: *“In VR, I don’t interpret the design - I experience it. That changes how I critique completely.”*

This quote reflects a broader transformation in evaluative practice, where critique moves from interpretation-based judgment to experience-based assessment, thereby increasing the relevance and impact of feedback.

#### **4.3. Staff Immersion: From Observer to Participant**

One of the most significant and novel contributions of this study is the identification of staff immersion within student work, a phenomenon that fundamentally redefines the role of the lecturer in the critique process.

In traditional studio settings, lecturers operate primarily as external observers, evaluating student work from outside the design through drawings and models. However, in VR environments, staff become immersed participants, actively engaging within the student’s design space.

This shift results in:

- Deeper engagement with design proposals
- More empathetic and user-centred critique
- Context-driven and situational feedback

By entering the design, lecturers are able to experience the spatial and experiential qualities of the project as users, rather than interpreting them abstractly. This aligns with theories of embodied cognition, which emphasise that understanding is enhanced through direct interaction with environments [3].

Furthermore, this immersive engagement supports a more dialogical and collaborative critique process, where feedback emerges from shared experience rather than hierarchical evaluation. Similar findings have been reported in immersive learning research, where VR facilitates deeper interaction and engagement between participants [5].

This transformation from observer → participant → embedded critic represents a critical pedagogical advancement, positioning VR as a tool that not only enhances student learning but also reshapes teaching practice within architectural education.

#### 4.4. The 2D vs VR Evaluation Gap

The comparative analysis between traditional and immersive evaluation modes reveals a clear and consistent gap across key dimensions of architectural critique. Table 2 summarises these differences.

**Table 1** The comparative analysis between traditional and immersive evaluation modes

Aspect	2D Evaluation	VR Evaluation
Spatial understanding	Abstract	Experiential
Feedback quality	General	Specific
Engagement	Moderate	High
Error detection	Limited	High

The findings indicate that VR-based evaluation consistently outperforms traditional methods across all measured dimensions. In particular, the shift from abstract to experiential spatial understanding significantly enhances students' ability to interpret and evaluate design proposals.

The improved feedback specificity observed in VR environments reflects the reduction of ambiguity in design communication, a known limitation of 2D representations [6]. Additionally, the increased level of engagement suggests that immersive environments promote active participation and sustained attention, which are critical for effective learning [3].

The ability to detect errors more effectively in VR further reinforces its value as an evaluative tool. By enabling real-time exploration and interaction, VR allows both students and lecturers to identify design issues that may remain hidden in static representations [10].

#### 4.5. Integration of Findings within the Research Framework

These findings are further contextualised within the broader research design and analytical framework (Figure 5), which illustrates how the study integrates participants, methodology, VR intervention, and data analysis to generate meaningful outcomes.

The framework demonstrates how a mixed-methods approach, combining quantitative analysis (Wilcoxon signed-rank test) and qualitative thematic analysis, enables a comprehensive evaluation of the impact of VR on:

- Design evaluation processes
- Critique quality and feedback depth
- Lecturer engagement and immersion

The convergence of quantitative and qualitative findings strengthens the validity of the results, confirming that the observed improvements are both statistically significant and experientially meaningful [1].

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## **5. Discussion**

The findings of this study demonstrate that Virtual Reality (VR) does not merely enhance existing learning processes in architectural education; rather, it redefines the nature of design evaluation itself. While previous research has largely focused on the benefits of VR for visualisation and engagement, this study advances the argument that immersive technologies fundamentally transform how architectural knowledge is constructed, interpreted, and critiqued within the design studio.

### **5.1. From Representation to Experience**

The central argument emerging from this study is that traditional architectural studios primarily evaluate representations of space, whereas VR enables the evaluation of experienced space. This distinction represents a critical pedagogical shift.

In conventional studio environments, design critique is mediated through drawings and models, which require both students and lecturers to interpret spatial conditions abstractly. As a result, evaluation is often constrained by the limitations of representational media, leading to partial or speculative understanding of spatial performance [7] [2]. In contrast, VR allows users to directly experience architectural space at full scale, enabling immediate and intuitive assessment of spatial qualities such as scale, proportion, and movement [3].

This transition from representation-based evaluation to experience-based evaluation shifts the focus of critique from how a design is depicted to how it is lived and perceived. Consequently, architectural evaluation becomes more aligned with the realities of human occupation and use, thereby increasing its relevance to both education and professional practice [6].

### **5.2. Alignment with Constructivist Learning Theory**

The findings strongly align with constructivist learning theory, which posits that knowledge is actively constructed through interaction, experience, and reflection rather than passively received [11]. Within a VR-enabled studio, students are not merely observing representations of architecture but are actively engaging with spatial environments, making decisions, and reflecting on their design in real time.

This active engagement supports deeper cognitive processing, particularly in relation to higher-order thinking skills such as analysis, evaluation, and synthesis. By enabling students to test and experience their designs directly, VR facilitates a more iterative and reflective design process, which is central to constructivist pedagogy [5].

Furthermore, the interactive nature of VR fosters a more student-centred learning environment, where learners take an active role in constructing knowledge through exploration and experimentation. This contrasts with traditional critique models, which may position students as passive recipients of feedback.

### **5.3. Embodied Cognition and Spatial Understanding**

The study's findings also resonate strongly with theories of embodied cognition, which suggest that learning is deeply rooted in bodily interaction with the environment. In architectural education, where spatial understanding is fundamental, the ability to physically navigate and experience space plays a crucial role in knowledge construction.

VR enables this form of embodied interaction by allowing users to move through and engage with architectural environments in real time. This immersive engagement enhances spatial cognition by linking perception, movement, and understanding, thereby reducing the cognitive gap between representation and experience [3] [5].

The observed improvement in students' ability to identify design flaws, assess circulation, and evaluate spatial relationships can therefore be understood as a direct outcome of embodied spatial experience, rather than abstract interpretation. This highlights the importance of integrating sensory and experiential dimensions into architectural pedagogy.

#### 5.4. Experiential Learning and Iterative Design

The findings further support experiential learning theory, which emphasises learning through concrete experience, reflection, and active experimentation [9]. In the context of this study, VR provides a platform for students to engage in a continuous cycle of:

- Experiencing the design (VR walkthrough)
- Reflecting on its performance
- Refining design decisions
- Re-evaluating outcomes

This iterative process enhances design evaluation by allowing students to immediately test and adjust their ideas within an immersive environment. Such real-time feedback loops are difficult to achieve in traditional studio settings, where evaluation is often delayed and mediated through static representations.

Moreover, experiential learning in VR extends to lecturers, who also engage in the design as participants. This shared experiential context enhances the quality of critique by grounding feedback in direct observation and interaction rather than interpretation alone.

#### 5.5. Redefining the Role of the Lecturer

A particularly significant contribution of this study is the reconceptualisation of the lecturer's role within the design studio. In traditional settings, lecturers function primarily as external evaluators, interpreting student work from a distance. However, in VR environments, lecturers become immersed participants, engaging directly with the design space.

This shift enables:

- More context-aware and precise feedback
- Increased empathy with user experience
- Enhanced dialogue between student and lecturer

Such transformation aligns with contemporary perspectives on collaborative and participatory learning, where knowledge is co-constructed through shared experience [5]. The lecturer is no longer positioned solely as an authority figure but as a co-explorer within the design environment, facilitating a more dynamic and interactive critique process.

#### 5.6. Implications for Architectural Pedagogy

Collectively, these findings suggest that VR has the potential to redefine architectural pedagogy by shifting the focus of design evaluation from representation to experience. This has several important implications:

- Architectural curricula should move toward integrating immersive evaluation as a core component rather than a supplementary tool
- Critique practices should evolve to incorporate experiential and interactive feedback mechanisms
- Teaching approaches should emphasise embodied and experiential learning to enhance spatial understanding

However, the successful implementation of such changes requires careful consideration of contextual challenges, including access to technology, training, and institutional readiness [4] [8]. Without addressing these factors, the transformative potential of VR may not be fully realised.

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## 6. Conclusion

This study set out to investigate the role of Virtual Reality (VR) in transforming architectural design evaluation and critique within the context of Nelson Mandela University. The findings demonstrate that VR does not merely function as an enhancement to existing pedagogical practices, but rather introduces a fundamental shift in how architectural work is evaluated, experienced, and understood.

At its core, VR repositions architectural critique from a visual and representational review process to an immersive and experiential evaluative practice. Unlike traditional two-dimensional (2D) methods, where spatial understanding relies on abstraction and cognitive reconstruction, VR enables direct engagement with architectural space at full scale. This transition significantly reduces interpretive ambiguity and allows both students and lecturers to assess design performance through lived experience rather than inferred representation.

The study confirms that VR contributes to a measurable improvement in design evaluation accuracy. Students demonstrated an enhanced ability to identify spatial inconsistencies, assess scale and proportion, and evaluate circulation patterns within immersive environments. These findings support existing research which indicates that immersive technologies improve spatial cognition and facilitate more precise interpretation of complex environments.

In addition, the integration of VR into critique processes resulted in a notable enhancement in the depth and quality of feedback provided by academic staff. Immersive evaluation enabled lecturers to deliver more specific, context-aware, and actionable critique, grounded in direct spatial experience rather than abstract interpretation. This aligns with prior studies highlighting the capacity of VR to improve communication and reduce ambiguity in architectural discourse.

A particularly significant contribution of this research is the identification of staff immersion within student work. VR enables lecturers to move beyond the role of external observers and become embedded participants within the design environment, fostering deeper engagement and more empathetic critique. This shift reflects broader developments in immersive pedagogy, where learning and evaluation are increasingly understood as shared, experiential processes.

Furthermore, the study demonstrates that VR effectively bridges the gap between design intent and spatial experience. In traditional studio settings, discrepancies often arise between what students intend and what lecturers interpret, due to the limitations of representational media. By enabling both parties to experience the design directly, VR reduces this disconnect and supports more accurate and meaningful communication of architectural ideas.

Taken together, these findings position VR as a transformative pedagogical tool capable of reshaping architectural education. However, the successful integration of immersive technologies requires careful alignment with curriculum design, adequate training for both students and staff, and institutional investment in infrastructure. Without these supporting conditions, the full potential of VR may not be realised, particularly within resource-constrained educational contexts.

In conclusion, this study contributes to the growing body of knowledge on immersive learning by proposing a shift toward experience-based architectural evaluation, where design is assessed not as a static representation but as a dynamic, lived environment. This paradigm shift has significant implications for the future of architectural pedagogy, suggesting that immersive technologies such as VR should be embedded as core components of design studio practice rather than treated as supplementary tools.

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## **Compliance with ethical standards**

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### *Statement of ethical approval*

Ethical clearance for this study was granted by the Human Research Ethics Committee of Nelson Mandela University (Ethics Approval Number: [1935 / Approval]). All participants provided informed consent, and the study complied with institutional and international ethical standards for research involving human participants.

### *Statement of informed consent*

Participants were recruited voluntarily and provided informed consent prior to participation. The study ensured that participants were fully informed about the nature, purpose, and procedures of the research, including their right to withdraw at any stage without penalty. Measures were implemented to protect participant confidentiality and privacy, including anonymisation of data and secure storage on encrypted institutional platforms.

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