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Virtual Reality Application within the Faculty of Engineering, the Build Environment and Advanced Technology: Focusing on Architectural Engineering

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Abstract: This paper explores the transformative potential of Virtual Reality (VR) within the Faculty of Engineering, the Built Environment, and Advanced Technology, with a specific focus on architectural engineering education in South Africa. VR is emerging as a critical medium for enhancing spatial cognition, design comprehension, and experiential learning. Architectural engineering students, in particular, benefit from immersive visualization, which allows for a deeper understanding of structural relationships, materiality, and user experience in built environments.

Grounded in phenomenology and spatial cognition theories, this study investigates how VR can be integrated meaningfully into architectural project workflows. Astudy conducted at the Nelson Mandela University, involving a studio-based VR intervention showed that 80% of students reported significant improvements in spatial awareness and design quality[1]. Despite these promising outcomes, adoption across South African institutions remains limited due to financial, infrastructural, and capacity-related challenges[2][3].

The findings underscore the importance of strategic investment in immersive technologies and staff training to ensure equitable and sustainable VR integration. Beyond education, this research points to broader applications of VR in collaborative design, virtual site simulations, construction planning, and stakeholder engagement. The study advocates for a future-oriented pedagogical shift that not only enhances academic outcomes but also prepares graduates for an increasingly digital and interdisciplinary professional landscape.

Keywords: Architectural engineering, Augmented Reality (AR), Immersive learning, perception of space, Virtual Reality (VR).

1. INTRODUCTION

The integration of Virtual Reality (VR) technology into the disciplines housed within the Faculty of Engineering, the Built Environment and Advanced Technology marks a transformative shift in how students engage with spatial and design concepts. In architectural engineering education specifically, VR presents a significant advancement over traditional two-dimensional representations such as technical drawings and scale models. By enabling immersive interaction with three-dimensional environments, VR fosters improved spatial cognition, design intuition, and problem-solving skills-critical competencies in an evolving professional landscape.

In the South African context, however, the adoption of VR in architectural education remains uneven, constrained by systemic barriers. These include limited financial resources, insufficient access to up-to-date VR equipment, and inadequate training for academic staff [2]. Without the capacity to fully implement immersive technologies, many institutions-particularly those in under-resourced or rural settingsare unable to provide equitable learning experiences aligned with global standards. Infrastructural deficits, such as outdated computer labs and unreliable technical support, further hinder the practical application of VR within studio-based learning environments [3].

Nelson Mandela University and similar institutions exemplify both the potential and the challenges of this technological transition. While some students are exposed to VR-assisted learning, others remain disconnected due to gaps in access, institutional readiness, and pedagogical support [1]. These disparities raise important questions about inclusivity, curriculum innovation, and the digital readiness of the broader higher education sector.

Despite these hurdles, the pedagogical promise of VR remains compelling. This paper investigates the integration of VR into architectural engineering education through the theoretical lenses of phenomenology and spatial cognition. It further highlights the role of VR in reshaping learning environments, advocating for strategic investment and institutional collaboration to unlock its full potential. By doing so, the study contributes to the discourse on digital transformation in South African higher education and suggests pathways for extending VR applications into other engineering and built environment disciplines.

2. CHALLENGES IN IMPLEMENTING CURRENT TECHNOLOGIES

Nelson Mandela University (NMU), situated within the broader context of South African higher education, is actively exploring the integration of Virtual Reality (VR) into its architectural engineering programmes. While the institution is committed to innovation within the Faculty of Engineering, the Built Environment and Technology (EBET), several challenges hinder the full-scale adoption of advanced technologies like VR. These challenges are reflective of broader national issues but are experienced in distinct ways at NMU due to local constraints in infrastructure, funding, and institutional readiness.

2.1. Resource Constraints

NMU, like many South African universities, faces ongoing financial pressures that limit its ability to invest in emerging educational technologies.

Limited Access to VR Equipment: The Architecture Department at NMU currently lacks access to VR headsets, advanced rendering machines, or immersive design software. While efforts are underway to access funding through the Department of Higher Education and Training (DHET), the size and distribution of national grants often fall short of institutional needs [2]. As a result, students have minimal or no exposure to VR during their academic journey.

Inadequate Funding for Training Workshops: As per Dude (2023), limited funding also restricts the university's ability to host VR-focused workshops for staff and students. This has delayed the structured introduction of VR technologies into the studio environment and broader curriculum. VR remains a recent and limited feature in NMU's built environment education, often introduced informally or through pilot projects.

2.2. Training Deficiencies

Successful integration of VR requires well-trained educators and technically proficient students. At NMU, capacity gaps exist at both levels.

Faculty Development Needs: A significant proportion of lecturers in the School of Architecture have not received formal training in digital teaching tools or VR integration strategies. This has led many issues tying up to Khumalo (2020) statement on training of staff and instructors. Many lecturers are currently continuingtheir reliance on basic 3D software for building forms; traditional analogue methods such as hand drawing and physical model-making for design critics, limiting students' exposure to digital innovation.

Varying Student Digital Skills: From Nkosi (2021), NMU draws a large number of students from under-resourced schools where exposure to digital tools is minimal. Many first-year students enter the programme with no experience in using computers, CAD software, or digital design tools. For the past couple of years, an Introductory computer literacy courses have been required at the beginning of each academic years, before trusting students to effectively engage with even basic architectural software, let alone immersive technologies.

2.3. Infrastructure Limitations

The university's physical and digital infrastructure is just starting to be equipped to support immersive technologies in teaching and learning environments.

Outdated Computer Labs: Computer labs at NMU's School of Architecture are currently limited to basic drafting and modelling software, such as AutoCAD, SketchUp and Revit. They are not equipped with the advanced processing capabilities required to run VR environments, and there is currently no dedicated VR lab on campus. We are currently running projects using a handful of VR gears, with access to free online software from SimLab.

Connectivity and Load Shedding: The majority of Universities in South Africa are still experiencing power cuts and failure often, more than expected [1]. Frequent load shedding and unstable internet connectivity further complicate the use of cloud-based platforms and real-time rendering tools. These infrastructural issues disrupt both in-person and online teaching, impeding sustained engagement with technology-enhanced learning.

2.4. Access Disparities

As a public university serving a diverse student body, NMU must navigate pronounced disparities in student access to digital tools and resources. According to Nkosi (2021) and Dude (2023)There is a great financial and resource gaps between learners accessing South African universities from a rural background, opposed to those coming from urban cities.

Technological Inequity: Students from urban areas often arrive with greater digital proficiency and access to personal devices, while those from rural or township schools may encounter digital learning environments for the first time at university. NMU offers limited lab access and support services, which are often oversubscribed, especially during design submission periods.

Economic Barriers: Many NMU students from lower-income backgrounds cannot afford personal laptops, data, or design software licenses. This is made evident by the numerous students strikes South African universities experience at the beginning of every academic year. While the university makes an effort to provide shared resources, such as computer labs and open-access facilities, the demand far exceeds the available infrastructure, reinforcing existing inequalities.

2.5. Resistance to Change

Cultural and institutional resistance within NMU also poses a barrier to adopting new digital pedagogies. According to Khumalo (2020) and Nkosi (2021), many South African universities are finding it difficult, attracting younger academics. This complexity slows down to drive to change, the willingness to embrace advanced technologies for teaching and learning.

Reluctance Among Academic Staff:While some faculty members are enthusiastic about digital innovation, others remain attached to conventional methods, preferring to use pen-and-paper design processes or avoiding technology-intensive workflows. This cultural resistance slows the broader adoption of immersive technologies within the department.

Student Hesitance: Students unfamiliar with VR or digital tools may initially be reluctant to engage with these technologies. This hesitance is often rooted in low digital confidence and fear of failure, particularly among students from disadvantaged schooling backgrounds.

2.6. Curriculum Integration

Incorporating VR into NMU's architectural engineering curriculum requires both academic reform and administrative support.Dude (2023) called for the need to rethink, redesign and re-align universities curriculums to align themselves with the advanced technologies requirements. Although it may take time, it would be a good process to balance traditions to local practices.

Curriculum Development Challenges: NMU is only beginning the process of aligning its built environment curriculum with emerging technologies. A full-scale curriculum overhaul to include VR as a core design and visualization tool is a long-term undertaking that involves both policy revision and resource mobilization.

Balancing Tradition and Innovation: Faculty members must balance the need to preserve foundational architectural principles with the imperative to adopt new technologies. Given the time constraints of semester-based design projects, integrating VR without overwhelming students or staff remains a key concern.

Addressing these institution-specific challenges is essential for NMU to effectively implement VR and other advanced technologies in architectural education. By investing in digital infrastructure, expanding training opportunities, and fostering a culture of innovation, NMU has the potential to become a leader in immersive architectural education in South Africa. Strategic planning and inclusive policy development will be critical to ensuring that all studentsregardless of backgroundare prepared to thrive in a technologically dynamic built environment sector.

3. Theoretical Frameworks

The use of Virtual Reality (VR) in architectural education at Nelson Mandela University (NMU) is guided by two core theoretical frameworks: phenomenology and spatial cognition. These theories support the integration of immersive technologies into design learning by focusing on how users perceive, experience, and interpret architectural space. In an educational environment where students often come from diverse and under-resourced backgrounds, such frameworks offer a strong foundation for inclusive, engaging, and effective learning experiences.

3.1. Phenomenology of Space

Phenomenology, as a philosophical and design framework, places emphasis on the lived experience of spacehow individuals perceive, move through, and emotionally engage with their environment. This approach shifts the focus in architecture from merely composing forms and functions to designing for human experience [4].

At NMU, VR is being explored as a medium through which architectural students can engage with their design work from within the space itself, rather than through traditional two-dimensional plans or static models. For instance, by walking through a virtual model of a library or housing complex, students are encouraged to reflect on how people will feel, orient, and move through the space. This direct engagement supports the development of empathetic, user-centered design thinking.

Key concepts in phenomenologysuch as intentionality, embodiment, and the lifeworldare central to this process. Through VR, students not only observe their designs but experience them as active participants, simulating real-world use and testing how materials, light, and form might influence user perception. This sensory immersion aligns with phenomenological principles and has been shown to enhance spatial understanding and emotional engagement in design [5][6]. The fig. 1 below illustrates the theory of Phenomenology and its key concepts in architectural education.

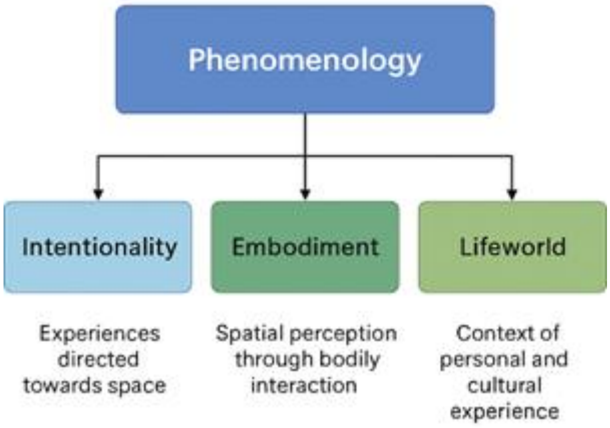


Figure 1: the theory of Phenomenology and its key concepts in architectural education.

By simulating real spatial contexts, NMU students are also able to understand cultural and contextual differencesa critical component of architectural education in a South African context where spatial justice and inclusivity are ongoing concerns.

3.2. Spatial Cognition

Spatial cognition refers to the mental processes involved in acquiring, organizing, and using spatial information. This includes skills like navigation, spatial memory, visual-spatial reasoning, and mental rotationall of which are fundamental in architectural design and problem-solving [7].

At NMU, VR is being tested as a tool for enhancing students' spatial abilities by offering a fully immersive, manipulable 3D environment where abstract ideas become tangible. Students working in virtual studios can explore their building designs from different angles, move through them in real-time, and observe how users might experience flow, movement, and orientation. This hands-on interaction promotes the development of cognitive mapsinternal mental representations of spaceand strengthens understanding of spatial relationships between objects and volumes [8].

The immersive nature of VR also supports environmental learning, as students repeatedly engage with simulated settings, building a deeper awareness of scale, proportion, and human circulation. This experiential method aligns well with constructivist educational theories, emphasizing learning through doingespecially valuable for NMU's diverse student body, many of whom have limited prior exposure to design technology.fig. 2 below illustrates the theory of Spatial Cognition and its key concepts in architectural education.

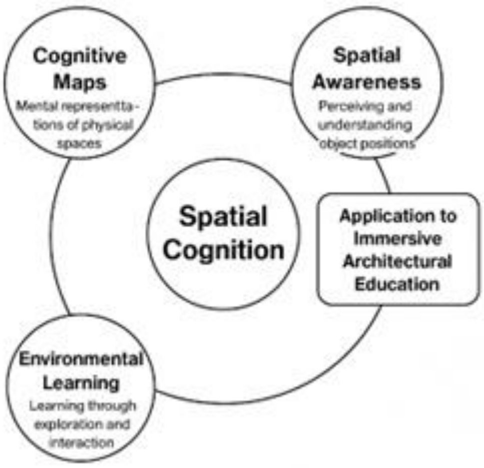


Figure 2: the theory of Spatial Cognition and its key concepts in architectural education.

Recent studies confirm that VR significantly enhances spatial cognition in design learning environments, improving students' ability to interpret complex spatial data and produce higher-quality designs [9][10].For NMU, where access to physical model-making resources may be limited, VR provides an equitable alternative that allows for rich, repeated practice in spatial exploration.

By applying the frameworks of phenomenology and spatial cognition, Nelson Mandela University aims to foster a more engaging, intuitive, and equitable approach to architectural education. The use of VR grounded in these theories not only advances students' technical capabilities but also cultivates human-centered, context-sensitive design thinking skills that are essential in preparing graduates for the dynamic challenges of the 21st-century built environment.

4. Methodology

This study adopts a mixed-methods approach, grounded in a design-based research model, to explore the application of virtual reality (VR) in architectural education at Nelson Mandela University (NMU). The focus is on a design studio project involving the conceptual development of a small one-bedroom house, comprising a lounge, dining area, kitchen, bathroom, and bedroom. The methodology is structured around three core components: project design, VR equipment and setup, and user interaction.

4.1. Project Design

The selected project; a small 40 square metre house, serves as a foundational exercise for introducing architectural students to spatial planning, scale, and user-cantered design. At NMU, this project has been embedded in the early design curriculum to enhance students' understanding of domestic spatial relationships and circulation. Following the design objectives set by Gwatiringa(2020), the objective of this project is to integrate VR into the design process to improve students' spatial cognition and phenomenological awareness of space, using immersive environments to simulate real-life experience.Fig. 3 illustrates the flowchart of the students' design project.

Key Components Include:

Educational Objectives: The project focused on enhancing students' spatial reasoning, improving design skills, strengthening their design thinking, and understanding of architectural scale and user experience through immersive engagement.

Content Development: Students were task to model a one-bedroom house using standard 3D modelling software such as SketchUp or Revit, which is then exported to a free VR platforms like SimLab viewer or Unity. These models are reviewed and iterated upon collaboratively with the researcher during VR walkthroughs sessions.

Scenario Building: Guided walkthroughs are developed to encourage students to experience the space from the user's perspective. Students were required to perceive themselves utilising the space and performing basic tasks such as cooking in the kitchen or moving from the bedroom to the bathroom, reinforcing phenomenological and cognitive theories.

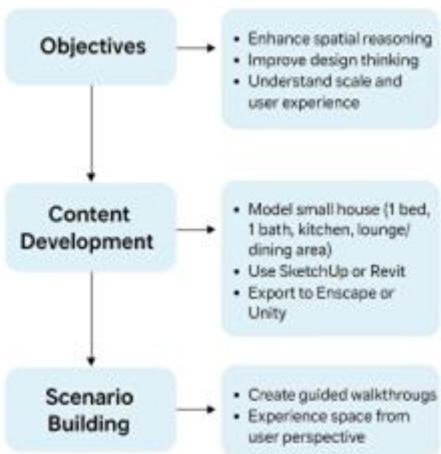


Figure 3: Small house project design flowchart, Using an Immersive technology.

4.2. VR Equipment and Setup

The technological implementation at NMU involves commercially accessible VR hardware, sourced through limited institutional funding (The Nelson Mandela University's Teaching Development and Innovation Funds). The hardware and software setup aims to balance affordability with functionality.

Key Components:

Head-Mounted Displays (HMDs): This study focused on the use of the VR Gear Meta Quest 3. This Gear was selected based on its wireless capabilities and compatibility with BIM design, rendering software used within the Faculty of Engineering, the Built Environment and Advanced Technology.

Motion Controllers: These controllers come as a pair, along with the VR Gear Meta Quest 3. These hands on joysticks allow students to navigate through their virtual models, offering tactile engagement and intuitive control of design elements. Fig. 4 belowshows the VR Gear Meta Quest 3 ready to be used in studio.

Tracking and Software Systems: Positional tracking systems embedded within the VR Gear ensure real-time movement, and quick reflection time in the virtual space. Software like SimLab viewer and Unity are used to integrate student designs into VR environments.

Figure 4: The VR Gear ready to be used in the studio project.

This setup allows students at NMU to move beyond static models, engaging directly with spatial proportions, lighting conditions, and user pathways elements often abstract in traditional 2D and 3D representations.

4.3. User Interaction

User interaction in VR is key to translating design intent into lived experience. At NMU, user interaction is categorized into Immersion and Manipulation, both critical for spatial understanding and learner engagement.

4.3.1. Immersion

According to Radianti et al (2020), Immersion refers to the feeling of presence within the virtual environment. Students walk through their designs in first-person perspective, observing space from human scale.Fig. 5 belowshows the project's immersive strategies and objectives, illustrating targeted sensory elements for a successful VR project.

Key Elements:

Multisensory Input: The project, through VR environment, aimed at producing high-resolution graphics and 3D audio simulate real environments, heightening realism and user awareness.

Contextual Feedback: The use of controllers allows the students to experience haptic feedback. The controllers will provide vibration feedback during object interaction (e.g., touching walls, bumping in furniture), reinforcing spatial boundaries created within the VR system.

Narrative Anchoring: Real-life design prompts such as our small house design ground the virtual experience in user empathy and real-world needs and parameters.

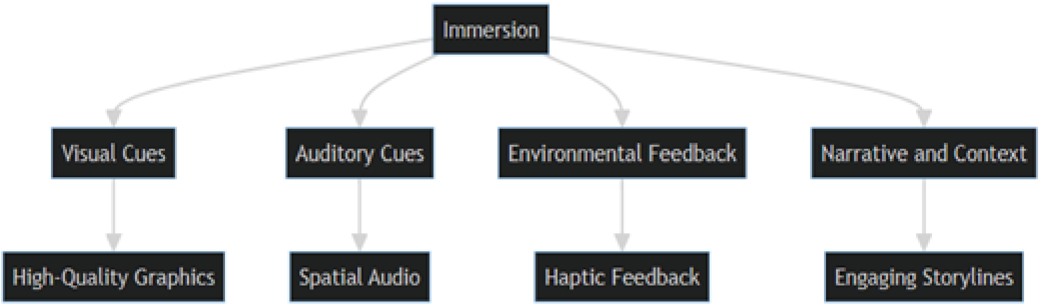


Figure 5: the project's immersive strategies and objectives, its key aspects and expected outcomes.

4.3.2. Manipulation

According to Jensen and Konradsen (2020), Manipulation enables active engagement with virtual models. At NMU, students are just starting to use motion controls to test spatial arrangements and iterate in real time. Fig. 6 Snap pic of student manipulating the small house project in the VR environment.

Key Elements:

Object Interaction: Using SimLab VR highLights, Students have just started learning how to move furniture, test door swings, take notes, or adjust room sizes, helping them understand scale and proportion. Because this is a paying software, and with our restricted fundings, we have only been able to use this for a 3-month period only.

Navigation Tools: The imbedded fly-through, and walk-through modes in the SimLab simulations allow students to experience their designs from different perspectives, enhancing their spatial cognition.

Problem-Solving Tasks: Exercises such as remodelling the living space orreconfiguring the small house's bathroom layout to improve circulation aim to reinforce our students'the design-thinking and problem-solving skills.

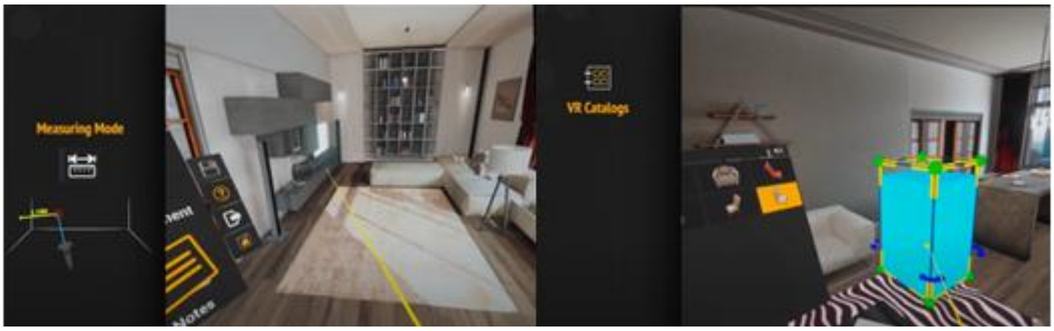


Figure 6: workflow of a student manipulating the small house project in the VR environment.

5. Survey Administration

To assess the impact of VR on students' spatial understanding and design skills, two surveys were conducted: one prior to the introduction of VR technology through the small design projects in studio and another following its implementation. These surveys aimed to capture the evolution of the users' perceptions regarding spatial awareness and their overall design capabilities.

5.1. Pre-VR Introduction Survey

The first survey aimed to evaluate users' existing understanding of spatial concepts and their familiarity with current technologies in architectural design. It will gather baseline data on participants' prior knowledge, attitudes, and expectations regarding VR in architectural education.

Key objectives include:

1. Assessing Prior Knowledge: Understand participants' familiarity with architectural concepts and VR technology.
2. Evaluating Attitudes: Gauge perceptions of VR as an educational tool.
3. Identifying Expectations: Capture what participants hope to achieve from the VR experience.

We are focusing on two major Components:

A- Quantitative Questions: Creswell & Creswell (2022) explain thatquantitative research questionsare "specific, narrow, and measurable," typically structured to collect data using instruments like Likert-scale items, multiple-choice questions, and numerical indicators, enabling statistical analysis.

Students were tested on: Their familiarity with technology, where they received ratings from their comfort level with various design technologies on a scale from 1 (not comfortable) to 5 (very comfortable); Following by questions on spatial awareness rating, where students assessed their ability to visualise and manipulate spatial relationships in their designs, also on a scale from 1 to 5.

Example Q1: On a scale of 1 to 5, how familiar are you with virtual reality technology? (1 = Not at all familiar, 5 = Very familiar)

Example Q2: How likely are you to use VR in your architectural studies? (1 = Very unlikely, 5 = Very likely)

B- Qualitative Questions: Patton (2021) describes qualitative questions as those thatinvite open-ended responses, allowing participants to express their experiences, thoughts, and emotions in their own words.

These questions aim to explore meaning and understanding rather than quantify data.

Students were tested on: Open-Ended Responses, where they were asked to describe their experiences with traditional design methods and any challenges, they faced in understanding spatial relationships; Following by questions on their Perception of Technology, with questions focusing on students' thoughts about the role of technology in enhancing architectural design, particularly their perceptions of VR.

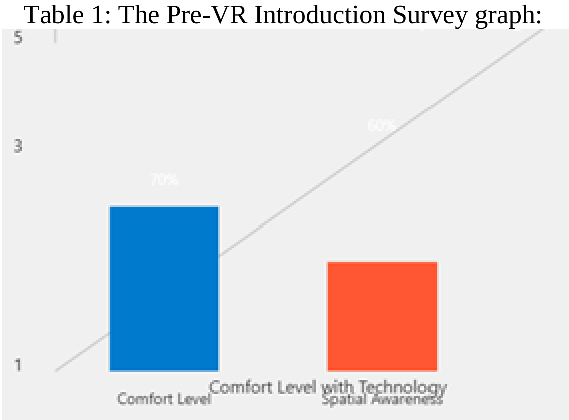
Example Q1: What are your thoughts on using virtual reality as a learning tool in architecture?

Example Q2: What specific benefits do you expect to gain from the VR experience?

Findings from this Pre-VR Introduction Survey:

- **Lack of Understanding:** The survey revealed that 70% of students felt uncomfortable using advanced design technologies, indicating a significant gap in technological proficiency.
- **Limited Experience with VR:** Approximately 65% of participants reported having little to no prior experience with VR technology.
- **Positive Attitude Towards VR:** About 80% of respondents expressed a positive view of VR as a potential tool for enhancing learning in architecture.
- **Expectations for Immersion:** 70% of participants anticipated that VR would provide a more immersive learning experience compared to traditional methods.
- **Concerns About Usability:** 55% of participants voiced concerns about the usability of VR technology, indicating a need for user-friendly interfaces.
- **Limited Spatial Perception:** Many students expressed difficulty in visualizing three-dimensional spaces from two-dimensional drawings. Over 60% reported struggling to grasp spatial relationships, which adversely affected their design quality.
- **Resistance to Change:** Several responses indicated a hesitance to adopt new technologies, with students citing a lack of training and support as barriers to embracing innovative tools. 75% of users were hesitant to adopt new technology, reflecting a significant barrier to integrating VR into architectural education.

Table 1: The Pre-VR Introduction Survey graph:



This Pre-VR Introduction Survey graph above illustrates the students' comfort levels with technology and their spatial awareness ratings. It shows a significant percentage of users feeling uncomfortable with technology and struggling with spatial awareness.

5.2. Post-VR Introduction Survey

The second survey aimed to evaluate the impact of VR on students' spatial understanding and design skills after its introduction asasmall house project. The studyevaluatestudents' experiences after engaging with VR technology in architectural education.

Key objectives include:

1. **Assessing Learning Outcomes:** Measure the effectiveness of VR in enhancing understanding of architectural concepts.
2. **Evaluating User Satisfaction:** Gather feedback on the overall satisfaction with the VR experience.
3. **Identifying Areas for Improvement:** Understand participants' suggestions for enhancing the VR experience.
4. **Measuring Intent for Future Use:** Determine the likelihood of participants using VR in future educational contexts.

We are focusing on two major Components:

Quantitative Questions: As described above, focusing on gathering measurable data, often using Likert scales or multiple-choice formats.

Students were tested on: Improvement in Spatial Awareness, where they were required to rate their spatial awareness after experiencing VR on a scale from 1 (no improvement) to 5 (significant improvement); Following by questions based on Skills Gained, where they had to assessed various skills gained through the VR experience, such as navigation, design manipulation, and spatial visualisation, using a similar rating scale.

Example Q1: On a scale of 1 to 5, how satisfied were you with the VR experience?(1 = Very dissatisfied, 5 = Very satisfied)

Example Q2: How much did your understanding of architectural concepts improve after the VR experience? (1 = No improvement, 5 = Significant improvement)

Qualitative Questions: As described above, focusing onallowing participants to express their thoughts and feelings in their own words.

Students were tested on: Their experience with VR, where they had to provide open-ended responses detailing their experiences using VR technology in their design projects; Following by questions focusing on perception of space, where they were required to focus on how VR changed their perception of space and design, asking students to articulate specific improvements in their understanding of spatial relationships.

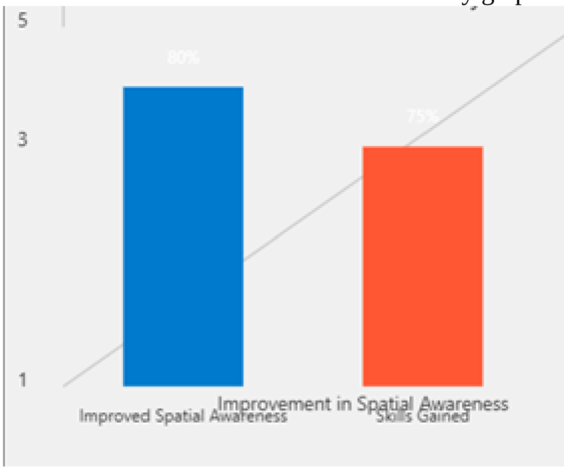
Example Q1: What did you find most beneficial about the VR experience in understanding architectural concepts?

Example Q2: What improvements would you suggest for future VR sessions?

Findings from this Post-VR Introduction Survey:

- **Enhanced Spatial Awareness:** The survey indicated that 80% of students reported a significant improvement in their ability to perceive and understand spatial relationships after using VR. Many articulated that VR allowed them to experience their designs in a more immersive and intuitive way.
- **Skills Development:** Students noted gains in critical skills, such as the ability to manipulate and navigate three-dimensional spaces. Over 75% felt more confident in their design capabilities, citing VR as a transformative tool for enhancing their creative processes.
- **Improved Understanding of Concepts:** 85% of participants reported a significant improvement in their understanding of architectural concepts after the VR experience.
- **High User Satisfaction:** 90% of respondents expressed satisfaction with the VR experience, rating it 4 or 5 on the satisfaction scale.
- **Increased Engagement:** 80% of users felt more engaged with the learning material during the VR session compared to traditional methods.
- **Positive Feedback on Immersion:** 78% of participants appreciated the immersive nature of VR, stating it enhanced their learning experience.
- **Intent for Future Use:** 82% of users indicated they would be likely to use VR in future architectural education, showing a strong interest in integrating this technology into their studies.
- **In-Depth Perception of Space:** Responses highlighted that VR facilitated a deeper understanding of spatial dynamics. Students expressed that they could better visualize how different elements interacted within a space, leading to more thoughtful and innovative design solutions. Many noted that experiencing their designs in VR helped them identify potential issues and improve their overall design quality.

Table 2: The Post-VR Introduction Survey graph:



The Post-VR Introduction Survey graph illustrates a marked improvement in both spatial awareness and skills gained after the introduction of VR.

The comparative analysis of the pre- and post-VR surveys at Nelson Mandela University reveals the transformative potential of virtual reality in architectural engineering education. Initially, students displayed limited spatial awareness and uncertainty in engaging with digital design toolshighlighting gaps commonly found in traditional, resource-constrained learning environments. However, following their immersion in the VR-based small house design project, students demonstrated significantly improved spatial comprehension, greater design confidence, and a more intuitive understanding of scale, form, and user experience. These outcomes affirm the value of incorporating VR into architectural curricula, particularly within contexts like NMU where such technologies can bridge educational disparities and better equip students for contemporary design challenges grounded in both phenomenological experience and spatial cognition.These findings also support the argument for broader implementation of VR in design curricula to prepare students for the complexities of modern architectural practice.

5. Conclusion

The integration of virtual reality (VR) into architectural education represents a transformative step toward bridging the gap between theoretical knowledge and experiential learning, particularly in the South African higher education context. This study, conducted at Nelson Mandela University, explored the implementation of a VR-based small house design projectfeaturing a one-bedroom, one-bathroom unit with a kitchen, lounge, and dining areaas a means to improve spatial understanding and design proficiency among architecture students.

By grounding the study in the theoretical frameworks of phenomenology and spatial cognition, we were able to deepen our understanding of how students perceive, engage with, and interpret architectural space within immersive environments. These frameworks were not only essential for informing the design of the VR experience but also for evaluating how immersive tools enhance embodied learning and spatial reasoning.

Our methodology, which included the careful design of VR content, strategic learning objectives, and hands-on engagement with Meta Quest 3 equipment, was effective in highlighting both the possibilities and the practical limitations of integrating immersive technologies at NMU. The comparative analysis of pre- and post-experience surveys revealed significant improvements in students' spatial awareness, confidence with design tools, and ability to conceptualize architectural space.

The findings of this research reinforce the importance of adopting VR as a core pedagogical tool within architectural curricula. As South African universities contend with limited resources and infrastructural challenges, this project demonstrates that even small-scale immersive interventionswhen carefully designed and theoretically groundedcan have a meaningful impact on student learning and creativity.

Moving forward, it is imperative that institutions like NMU continue investing in digital infrastructure, training, and curriculum integration strategies. Such efforts will not only equip students for the demands of 21st-century architectural practice but also foster a culture of innovation and inclusivity in architectural education across South Africa.

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