

VR-GUIDED WALL MURAL (VRGWM): AN IMMERSIVE, EMBODIED FRAMEWORK FOR SCALABLE MURAL SKILL DEVELOPMENT IN TVET AND COMMUNITY CONTEXTS

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Abstract: *This study presents the VR-Guided Wall Mural (VRGWM) as a practice-based innovation that integrates immersive Virtual Reality (VR) with manual mural execution to address limitations in conventional mural production. Traditional approaches remain highly dependent on artistic expertise and time-intensive processes, limiting accessibility and participation in educational and community contexts. Drawing on embodied cognition, experiential learning, and spatial cognition, this study proposes VRGWM as a structured framework that bridges virtual visualisation and physical execution through an iterative VR–Wall alternating loop. The approach was implemented in real-world mural projects involving students, educators, and community participants. Findings indicate that VRGWM enhances spatial understanding, improves participant confidence, and increases efficiency in mural production, particularly during the base-sketching stage. Importantly, the approach enables non-professional individuals to engage effectively in large-scale mural drawing. This study contributes by positioning VRGWM as a theory-informed and scalable framework aligned with digital transformation and TVET priorities.*

Keywords: *VR-guided mural; immersive learning; spatial cognition; experiential learning; virtual reality; digital creativity; community engagement*

Introduction

Public mural art is increasingly recognised as a powerful medium for placemaking, community engagement, and experiential learning. Within educational contexts, mural activities promote collaboration, creativity, and learner participation. However, conventional mural production remains highly dependent on artistic expertise, manual image-transfer techniques, and controlled working conditions, limiting scalability and accessibility for non-professional participants.

More critically, existing mural practices are predominantly technique-driven and lack a coherent pedagogical framework that connects spatial understanding with real-world execution. While digital tools such as projection systems and image tracing assist production, they remain largely procedural and do not sufficiently support the development of spatial cognition or embodied learning. As a result, mural practice continues to be perceived as an artist-dependent activity rather than a transferable skill within Technical and Vocational Education and Training (TVET) contexts.

In parallel, the advancement of immersive technologies, particularly Virtual Reality (VR), has demonstrated strong potential in supporting spatial learning, skills acquisition, and experiential engagement. However, current applications of VR in creative practices are largely limited to digital visualisation, with minimal exploration of its role in supporting real-world manual execution.

Addressing this gap, this study introduces the VR-Guided Wall Mural (VRGWM) as a practice-based innovation that integrates immersive VR visualisation with manual mural execution. This study contributes by positioning VRGWM as an embodied and scalable framework that bridges digital visualisation and physical execution, aligned with TVET and digital transformation agendas.

This study aims to examine how VRGWM enhances spatial understanding, improves execution efficiency, and expands participation in mural production within educational and community contexts.

Literature Review

Public mural art has been widely acknowledged as a significant medium for placemaking, urban regeneration, and community engagement. Studies have demonstrated that murals contribute to the enhancement of spatial identity, revitalisation of public environments, and promotion of social interaction within communities (Miles, 1997; Sharp et al., 2005; Zebracki, 2017). Within educational settings, mural activities are also recognised as participatory learning practices that foster collaboration, creativity, and learner ownership (Dewey, 1938; Wilson, 2013).

However, despite these recognised benefits, mural production remains largely dependent on artistic expertise, time-intensive processes, and technical precision. Conventional techniques such as manual sketching, grid transfer, and projector-based methods often require controlled conditions and specialised skills, limiting broader participation among non-professional practitioners (Lacy, 1995; McCormick, 2018). As a result, mural practice continues to be perceived as an expert-driven activity rather than an accessible skill that can be scaled within educational and community contexts.

Parallel to developments in mural practices, Virtual Reality (VR) has emerged as a powerful tool in education, particularly in supporting spatial learning, immersive engagement, and skill acquisition. VR environments enable users to experience full-scale visualisation, improving their understanding of spatial relationships, proportions, and environmental context (Winn, 1993; Roussou, 2004; Slater & Wilbur, 1997). More recent studies further highlight VR's effectiveness in enhancing learner confidence, engagement, and experiential understanding across various disciplines (Ibáñez & Delgado-Kloos, 2018; Radianti et al., 2020; Whyte, 2002). Despite the growing body of literature on mural art and VR-based learning, these two domains remain largely disconnected. Existing mural studies focus predominantly on artistic, social, and urban dimensions, while VR research is primarily centred on digital visualisation, simulation, and virtual environments. Limited attention has been given to how immersive technologies can support real-world manual creative practices, particularly in translating virtual spatial understanding into physical execution.

Furthermore, current studies often adopt a descriptive approach, emphasising the benefits of murals or VR independently, without critically examining their limitations or exploring their integration. This reveals a significant gap in the literature — specifically, the absence of a structured framework that connects immersive spatial visualisation with embodied, hands-on mural execution.

In addressing this gap, the present study positions VRGWM as an integrative approach that bridges mural practice and immersive technology. By combining VR-based spatial visualisation with manual drawing processes, VRGWM offers a novel pathway for transforming mural production into a scalable, skills-oriented, and pedagogically grounded activity. This integration not only expands participation beyond skilled artists but also contributes to the development of spatial cognition and experiential learning within TVET and community-based education contexts.

Theoretical Framework

This study is grounded in an integrative theoretical framework that combines **Embodied Cognition**, **Experiential Learning**, and **Spatial Cognition** to explain how immersive Virtual Reality (VR) facilitates mural skill acquisition through the VRGWM approach.

First, the concept of **embodied cognition** emphasises that learning is not solely a cognitive process but is deeply shaped by physical interaction with the environment (Wilson, 2002; Pallasmaa, 2005). In the context of VRGWM, participants engage in a continuous interaction between virtual visualisation and physical wall drawing. This interaction enables learners to construct knowledge through bodily experience, where perception, movement, and action are closely interconnected.

Second, **experiential learning theory** (Kolb, 1984) highlights that effective learning occurs through a cyclical process of experience, reflection, and active experimentation. The VR–Wall alternating loop embedded in VRGWM reflects this learning cycle, where participants observe the mural composition in VR, apply their understanding through manual drawing, and refine their work through iterative feedback. This process supports progressive skill development and reinforces learning through direct engagement.

Third, **spatial cognition theory** explains how individuals perceive, interpret, and organise spatial information (Winn, 1993). The immersive VR environment allows participants to

experience mural compositions at full scale, improving their ability to understand proportions, alignment, and spatial relationships before translating them into physical drawings. This enhances accuracy and reduces dependency on traditional grid or projection techniques.

Collectively, these three theoretical perspectives provide a unified explanation of how VRGWM supports mural skill development. Embodied cognition explains the role of physical interaction, experiential learning frames the iterative learning process, and spatial cognition accounts for improved understanding of scale and proportion. Together, they position VRGWM not merely as a technical tool, but as a structured, theory-driven approach to skills acquisition. This integrated framework addresses the gap identified in previous studies by linking immersive technology with real-world manual execution. It further strengthens the positioning of VRGWM as a pedagogically grounded innovation aligned with TVET principles, where learning is hands-on, iterative, and closely connected to real-world practice.

Methodology

This study adopts a **practice-based and design-oriented research approach**, focusing on real-world implementation of the VR-Guided Wall Mural (VRGWM) method within community and educational settings. The methodology emphasises embodied learning, iterative skill development, and spatial understanding through direct engagement in mural production activities.

Research Design and Context

The VRGWM approach was implemented in a series of mural projects involving students, educators, and community participants, including a key implementation in Kangar, Perlis, during World Town Planning Day 2025. The study prioritises real-world application rather than controlled experimental conditions, aligning with design-based and practice-led research principles.

Data collection was conducted through:

- Observational documentation of mural activities
- Process recording (photographs and visual documentation)
- Informal participant feedback during execution

This approach enables the study to capture authentic learning experiences, participant engagement, and practical feasibility of the VRGWM method.

VR Tools and Digital Environment

The VRGWM approach utilises immersive VR technology as a spatial guidance tool in the mural drawing process. The primary hardware used is the **Meta Quest 3 VR headset**, which enables full-scale immersive visualisation.

Several VR drawing and tracing applications support the process, including:

- *Stencil VR*
- *Contour*
- *SketchAR*
- *TraceArtist*

These applications allow users to visualise mural compositions at full scale, supporting proportion control, alignment, and spatial referencing prior to physical execution.

The integration of VR tools introduces a new paradigm in mural production, where digital visualisation and manual execution are interconnected. With basic training and guided practice, participants progressively adapt to the immersive environment, resulting in increased drawing speed, accuracy, and confidence over time.

VRGWM Drawing Process

The VRGWM method follows an iterative workflow that integrates immersive virtual visualisation with physical wall execution.

As illustrated in Figure 1, the process is structured around a VR–Wall alternating loop, where participants repeatedly switch between VR observation and manual drawing to refine spatial accuracy and execution.



Figure 1. VRGWM Process Framework Integrating Virtual Visualisation with Physical Execution

The process consists of four key stages:

1. VR–Wall Calibration

The mural composition is first aligned in the VR environment with the actual wall dimensions to ensure consistency in scale, proportion, and positioning.

2. Guided Manual Sketching

Participants begin sketching directly on the wall while using VR as a spatial reference for composition and proportion. As shown in Figure 2, the VR headset functions as a real-time spatial guide, enabling accurate translation of virtual imagery into physical drawing.

3. Iterative VR–Wall Loop

The drawing process involves repeated transitions between VR viewing and physical execution. Participants continuously adjust their sketches by rechecking alignment, scale, and spatial relationships within the VR environment.

4. Colouring and Final Execution

Once the base sketch is established, mural colouring is carried out using conventional techniques. At this stage, the drawing process becomes more efficient and collaborative, as the spatial structure has already been accurately defined.



Figure 2. VR-assisted mural sketching by a professional artist using a VR headset.

Evaluation and Validation Approach

To enhance methodological rigour, the effectiveness of the VRGWM approach is evaluated through three key indicators derived from real-world implementation.

First, **spatial accuracy** is assessed based on the consistency between VR visualisation and the final wall execution, particularly in terms of proportion, alignment, and composition.

Second, **participant confidence** is observed through engagement levels and behavioural responses during the mural process. Participants initially experience uncertainty when adapting to the VR environment; however, confidence increases progressively through repeated interaction within the VR–Wall loop.

Third, **execution efficiency** is evaluated based on the reduction in time required for base-sketching compared to conventional mural methods. The VR-guided approach enables faster and more structured sketching, particularly for non-professional participants.

As illustrated in Figure 3, even non-professional participants are able to translate VR-guided visualisation into accurate mural execution, demonstrating the inclusivity and scalability of the VRGWM approach.



Figure 3: VR-assisted mural drawing by a non-professional participant, demonstrating accurate execution.

Although this study adopts a qualitative and practice-based approach, the use of these indicators provides a structured framework for evaluating the practical effectiveness and educational potential of VRGWM in real-world contexts.

Discussion

The findings indicate that VRGWM represents a significant shift from conventional mural practices towards a more inclusive, technology-supported, and skills-oriented approach. By integrating immersive VR tools such as the Meta Quest 3 headset with applications including *Stencil VR*, *Contour*, *SketchAR*, and *TraceArtist*, mural production is transformed from an artist-dependent activity into a guided and learnable process.

A key observation from the implementation is the transition in participant experience throughout the drawing process. At the initial stage, participants often encounter difficulty in coordinating between the virtual environment and the physical wall, resulting in a sense of unfamiliarity and hesitation. However, through repeated engagement in the VR–Wall alternating loop, participants gradually adapt to the immersive environment. This adaptation reflects a cognitive adjustment process, where perception, movement, and spatial judgement become increasingly synchronised. Consequently, drawing performance improves in terms of speed, accuracy, and confidence.

This progression can be explained through the integration of embodied cognition, experiential learning, and spatial cognition theories. The continuous interaction between VR visualisation and physical drawing enables participants to construct spatial understanding through active engagement. The iterative nature of the VR–Wall loop aligns with experiential learning cycles, where observation, action, and refinement reinforce skill acquisition. At the same time, the immersive VR environment enhances users' ability to interpret scale, proportion, and spatial relationships, thereby reducing reliance on conventional projection or grid-based methods.

The effectiveness of VRGWM is further strengthened by advancements in VR hardware capabilities. The use of devices such as the Meta Quest 3, featuring a high-resolution 4K+ Infinite Display per eye, enables a Mixed Reality (MR) experience that blends virtual elements with the physical environment. This capability enhances spatial perception by allowing participants to visualise mural compositions directly within the real-world context, improving alignment, depth awareness, and proportional accuracy during execution.

Importantly, while VR headsets are often associated with gaming and entertainment, their application in VRGWM demonstrates a shift towards productive and socially engaged use. In this context, VR technology functions as an enabling platform for collaborative creative practice, supporting real-time visual guidance and active participation. This repositions VR from a passive consumption tool into an active medium for learning, production, and skill development.

From a practical perspective, VRGWM offers clear advantages in terms of efficiency and scalability. The reduction in time required for base-sketching, combined with increased participant confidence, enables larger and more diverse groups to participate effectively in mural projects. This is particularly relevant within educational and community contexts, where inclusivity and skill transfer are central objectives. The approach further suggests that mural production can be reframed as a technical and trainable competency within TVET, rather than a specialised artistic domain.

Nevertheless, several limitations should be acknowledged. The study primarily relies on qualitative observations and informal participant feedback, which may limit the generalisability of the findings. Additionally, the effectiveness of VRGWM may depend on user familiarity with VR technology, as well as access to appropriate hardware and applications. Future research should incorporate more structured evaluation methods, including quantitative performance indicators, learning outcome measurements, and longitudinal studies on skill retention.

Overall, the findings demonstrate that VRGWM extends beyond a technical innovation by offering a structured, theory-informed framework for skill development. By bridging immersive visualisation with physical execution, VRGWM contributes to the evolving discourse on digital innovation in creative practice and skills-based education. It presents a scalable and future-oriented model that aligns with the growing demand for digital literacy, experiential learning, and technology-enhanced pedagogy.

Conclusion

This study demonstrates that the VR-Guided Wall Mural (VRGWM) approach represents a meaningful convergence of immersive technology, embodied learning, and community-based creative practice. By integrating Virtual Reality with manual mural execution, VRGWM transforms mural production from an artist-dependent activity into a scalable, skill-oriented, and inclusive process.

The findings highlight that VRGWM enhances spatial understanding, improves participant confidence, and increases efficiency in mural execution, particularly during the base-sketching stage. More importantly, the approach repositions mural practice as a transferable competency that can be effectively integrated within Technical and Vocational Education and Training (TVET) contexts.

From a theoretical perspective, this study contributes by demonstrating how embodied cognition, experiential learning, and spatial cognition can be operationalised through immersive technology to support real-world skill acquisition. This integration offers a structured framework that bridges digital visualisation and physical execution, addressing a gap in existing literature.

Practically, VRGWM provides a viable model for expanding participation in mural production, enabling non-professional individuals to engage confidently in large-scale creative work. The approach also aligns with broader national priorities on digitalisation, artificial intelligence integration, and future-ready education, as outlined in the Rancangan Pendidikan Tinggi Malaysia 2026–2035.

Nevertheless, further research is required to strengthen empirical validation, particularly through quantitative measurement of learning outcomes, performance improvement, and long-term skill retention. Future studies may also explore the scalability of VRGWM across different disciplines and its potential integration with emerging AI-assisted creative tools.

In conclusion, VRGWM offers a forward-looking and sustainable framework for technology-enhanced creative skill development, contributing to both the advancement of public art practice and the evolving landscape of immersive, skills-based education.

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