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COMPARATIVE EVALUATION OF VR-GUIDED AND CONVENTIONAL MURAL TECHNIQUES: TOWARDS SCALABLE AND INCLUSIVE CREATIVE SKILL DEVELOPMENT

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Abstract: *This study presents a comparative evaluation of the VR-Guided Wall Mural (VRGWM) approach against two conventional mural production techniques, namely the grid method and projector-based tracing. Building on earlier studies that introduced and theoretically grounded VRGWM as a practice-based, theory-informed framework (Saaid et al., 2026A, 2026B), this paper extends the discussion through a structured comparative analysis based on nine explicit criteria: sketching speed, skill requirement, accuracy, scalability, accessibility, collaboration, cost, environmental dependency, and pedagogical value. Using a conceptual, demonstration-based approach informed by prior implementation evidence and the extant literature, the study develops an operationalised comparative matrix that qualitatively benchmarks VRGWM against the two established techniques. The analysis indicates that VRGWM offers distinct advantages in spatial-cognition support, execution speed, and inclusivity, particularly among non-professional participants, whereas conventional methods retain strengths in collaborative execution and cost efficiency but remain constrained by technical-skill dependency and environmental sensitivity. By situating VRGWM within embodied cognition and experiential learning theory, this study clarifies the mechanisms through which immersive guidance may lower barriers to mural skill acquisition, while explicitly acknowledging the limitations of single-user hardware dependency and unvalidated qualitative ratings. The resulting comparative matrix provides an empirically testable foundation for future quantitative studies and contributes a structured, replicable basis for positioning VRGWM within TVET and digital transformation agendas.*

Keywords: *VR-guided mural; comparative analysis; immersive learning; TVET; embodied cognition; digital transformation*

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Introduction

Public mural art continues to play a significant role in placemaking, community engagement, and experiential learning. However, conventional mural production methods remain highly dependent on artistic expertise, manual processes, and controlled working conditions, limiting broader participation and scalability.

In response to these challenges, the VR-Guided Wall Mural (VRGWM) approach was initially introduced as a practice-based innovation that integrates immersive virtual reality (VR) with manual mural execution (Saaid et al., 2026A). Early implementation demonstrated that VRGWM could enhance spatial accuracy, improve execution efficiency, and enable participation among non-professional users.

Subsequent research further advanced VRGWM into a structured and theory-informed framework grounded in embodied cognition, experiential learning, and spatial cognition (Saaid et al., 2026B). The study highlighted the role of the VR–Wall iterative loop as a key mechanism that bridges virtual visualisation and physical execution, positioning VRGWM as a pedagogically relevant approach within Technical and Vocational Education and Training (TVET) contexts.

Despite these developments, a critical gap remains in the literature: the lack of comparative evaluation between VRGWM and conventional mural techniques. Existing studies have yet to systematically examine how VRGWM performs relative to widely used methods such as grid-based drawing and projector-based tracing.

This study addresses this gap by conducting a structured comparative analysis of VRGWM and two conventional mural techniques, focusing on efficiency, accessibility, scalability, skill requirement, and pedagogical value. In doing so, the paper makes three contributions. First, it develops an explicit, criterion-based comparative framework, accompanied by operational definitions, that can be replicated or adapted in future empirical studies. Second, it synthesises evidence from prior VRGWM implementation studies (Saaid et al., 2026A, 2026B) and the broader VR-in-education literature to produce a literature-informed qualitative benchmarking of the three techniques. Third, it identifies specific, testable propositions and a research agenda for the quantitative validation of VRGWM's comparative advantages. The remainder of the paper is organised as follows: the Literature Review situates VRGWM within existing mural and VR-education scholarship; the Comparative Framework and Analysis section presents the criteria and the strengths-and-limitations matrix; the Methodology section outlines the conceptual, demonstration-based research design; the Research Discussion critically interprets the comparative findings and their implications; and the Conclusion summarises the contributions and outlines directions for future empirical research.

Literature Review (Compact & Connected)

Public mural art has long been recognised as a medium for placemaking, social engagement, and participatory learning (Miles, 1997; Sharp et al., 2005; Wilson, 2013). Within educational settings, mural activities support collaborative learning and creativity but often remain limited by technical skill requirements and time-intensive processes (McCormick, 2018).

Parallel to developments in mural practice, Virtual Reality (VR) has emerged as a powerful tool for spatial learning and immersive engagement. Studies have shown that VR enhances spatial

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cognition, supports embodied interaction, and improves task understanding in complex visual environments (Winn, 1993; Roussou, 2004; Radianti et al., 2020).

Recent work on VRGWM has begun to bridge these domains by integrating immersive visualisation with real-world mural execution. The initial study by Saaid et al. (2026A) introduced VRGWM as a practice-based innovation aimed at expanding access to mural production, particularly for non-professional users. This was further developed by Saaid et al. (2026B), who established VRGWM as an embodied and pedagogical framework aligned with experiential learning and TVET principles.

However, while these studies demonstrate the feasibility and educational value of VRGWM, limited attention has been given to its comparative performance against conventional mural techniques. This highlights the need for a structured comparative analysis to better position VRGWM within the broader context of mural practice and skills development.

Taken together, the literature reveals two parallel but previously unconnected trajectories: an established body of work on the social and pedagogical value of mural practice (Miles, 1997; Sharp et al., 2005; McCormick, 2018), and a growing evidence base on the cognitive and educational benefits of VR (Radianti et al., 2020; Makransky & Petersen, 2019). Notably, meta-analytic evidence on VR-based learning reports considerable variability in effect sizes across domains and task types (Makransky & Petersen, 2019), which suggests that the benefits of immersive tools cannot be assumed to transfer uniformly to hands-on, craft-based skills such as mural painting. Positioned against this backdrop, VRGWM (Saaid et al., 2026A, 2026B) represents an early attempt to test this transfer within a specific creative-practice context, yet its performance relative to entrenched conventional methods has not been systematically benchmarked. It is this specific comparative gap — rather than the general feasibility of VR-assisted mural work, which has already been established — that the present study seeks to address.

Comparative Framework & Analysis

This study adopts a conceptual comparative framework to evaluate three mural techniques:

1. VR-Guided Wall Mural (VRGWM)
2. Grid-based drawing method
3. Projector-based tracing method

The comparison is structured across nine performance criteria, selected to jointly capture the operational, pedagogical, and practical dimensions relevant to mural production in TVET and community contexts. Table 1 presents these criteria together with their operational definitions, which guide the qualitative assessment reported in Table 2 and Table 3.

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Table 1: Comparative Criteria and Operational Definitions

Criteria	Operational Definition
Sketching Speed	The time required to complete the initial base outline of a mural composition on a wall surface.
Skill Requirement	The level of prior artistic or technical proficiency needed to operate the method effectively.
Accuracy	The degree of proportional and spatial correctness achieved in the transferred composition.
Scalability	The capacity of the method to accommodate murals of varying sizes and levels of compositional complexity.
Accessibility	The ease with which non-professional or novice users can engage with and complete the method.
Collaboration	The extent to which the method supports simultaneous participation by multiple users.
Cost	The financial investment required for equipment, materials, or tools associated with the method.
Environmental Dependency	The degree to which the method's effectiveness is influenced by external conditions such as lighting, surface texture, or weather.
Pedagogical Value	The extent to which the method actively contributes to spatial learning, skill acquisition, and cognitive engagement.

The ratings presented in Table 2 and Table 3 constitute a literature-informed, expert-judgment assessment rather than a measured or statistically derived outcome. Ratings were assigned through a structured qualitative appraisal that triangulated: (i) documented outcomes from prior VRGWM implementation studies (Saaid et al., 2026A, 2026B); (ii) established characteristics of grid-based and projector-based techniques reported in the mural and public art literature (McCormick, 2018; Sharp et al., 2005); and (iii) observations from the demonstration exercise described in the Methodology section. This heuristic approach is appropriate for an early-stage, concept-validation study, but it necessarily carries limitations — including the absence of inter-rater reliability testing and quantitative performance measurement — that are addressed explicitly in the Scope and Limitation and Limitations sections below.

VRGWM Method

VRGWM represents a hybrid approach that integrates immersive visualisation with physical execution. The method enables users to perceive mural compositions at full scale through VR before translating them onto physical surfaces.

Grid Method (Conventional)

The grid method is a traditional technique widely used for scaling images onto large surfaces through proportional division.

Projector-Based Tracing

This method involves projecting an image onto a surface and tracing its outlines directly.
Table 2 consolidates the specific advantages and limitations of the three techniques discussed above, based on the criteria defined in Table 1.

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Table 2: Strengths and Limitations of VRGWM, Grid Method, and Projector-Based Tracing

Method	Advantages	Limitations
VRGWM	– Faster base-sketching through spatial guidance – Reduced dependency on advanced artistic skills – Flexible application across different mural scales – Supports inclusive participation and digital skill development	– Requires training to operate VR tools – Limited to individual use per device – Higher initial cost – Dependent on hardware readiness (battery, setup)
Grid Method	– Supports collaborative work among multiple artists – Suitable for large-scale murals Low cost and widely accessible	– Requires understanding of proportion and drawing skills – Time-consuming for complex compositions – Difficult for non-experts to interpret
Projector-Based Tracing	– Fast and accurate under suitable conditions – Low skill requirement	– Highly dependent on lighting conditions – Limited projection size – Not suitable for outdoor environments

Methodology

This study adopts a conceptual and demonstration-based methodology, focusing on comparative evaluation rather than full-scale empirical testing. The approach is designed to provide an initial analytical understanding of VRGWM in relation to conventional mural techniques.

Research Approach

The study integrates:

- Conceptual analysis of mural techniques
- Observational insights from prior VRGWM implementation (Saaid et al., 2026A; 2026B)
- Demonstration-based application of VR tools

Rationale for the Conceptual-Comparative Design

A conceptual and demonstration-based design was adopted deliberately, rather than as a default limitation. At this stage of VRGWM's development — following its initial practice-based introduction (Saaid et al., 2026A) and theoretical elaboration (Saaid et al., 2026B) — a structured qualitative comparison against established techniques is a necessary precursor to controlled empirical testing: it clarifies which criteria and metrics merit rigorous quantitative investigation and reduces the risk of testing hypotheses that are conceptually underspecified. The present design therefore functions as a benchmarking and hypothesis-generating stage within a broader, multi-phase research programme, the next phase of which is outlined in the Conclusion.

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VR Demonstration Setup

A practical demonstration of the VRGWM approach is conducted using:

- VR Hardware: Meta Quest 3 headset
- VR Drawing/Tracing Applications: Contour or SketchAR

The demonstration focuses on the base-sketching phase, where VR is used as a spatial guidance tool to support manual drawing on a wall surface. Unlike previous full mural implementations, this study utilises a controlled demonstration scenario to illustrate the workflow, interaction, and usability of VRGWM.

Demonstration Process

The VRGWM demonstration follows a simplified version of the VR–Wall iterative loop:

1. Visualising the mural composition in VR
2. Translating spatial understanding into manual wall sketching
3. Rechecking alignment through repeated VR interaction

This process highlights how immersive visualisation supports spatial cognition and drawing accuracy, even without completing a full mural execution.

Comparative Evaluation Framework

The evaluation is conducted through analytical comparison across the three methods introduced earlier (VRGWM, grid-based method, and projector-based tracing), structured according to the nine criteria and operational definitions presented in Table 1.

Scope and Limitation

This study does not include quantitative performance data, as full mural implementation is planned for future research; the current analysis instead provides a conceptual and exploratory foundation. Three specific methodological limitations should be noted. First, the comparative ratings reported in Table 2 and Table 3 reflect qualitative, literature- and demonstration-informed judgment rather than measured data, and no inter-rater reliability check was conducted. Second, the research team's direct involvement in developing VRGWM introduces a potential positionality bias; while assessments were grounded in documented evidence and in established characteristics of conventional methods reported in the literature, this bias cannot be fully eliminated without independent, blinded evaluation. Third, the demonstration exercise involved a single controlled scenario rather than a representative sample of users or mural contexts, limiting the generalisability of the observational insights. These limitations are addressed directly in the future research agenda outlined in the Conclusion.

Research Discussion

The evolution of mural production techniques reflects broader shifts in creative practice, from traditional skill-based approaches to digitally supported and immersive workflows. This study positions the VR-Guided Wall Mural (VRGWM) approach as a significant advancement within this trajectory, building upon conventional methods such as grid-based drawing and projector tracing while addressing their inherent limitations.

Historically, the grid method has been widely used as a reliable technique for scaling images onto large surfaces. Its strength lies in its collaborative potential, allowing multiple artists to work simultaneously across segmented sections of a mural. This makes it particularly suitable for large-scale public art projects. However, the grid method requires a strong understanding of

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proportion, spatial mapping, and drawing interpretation. For novice users, the abstraction of grid divisions often presents cognitive challenges, as the image must be mentally reconstructed from fragmented segments. As a result, while the method is technically robust, it remains skill-dependent and less accessible to beginners.

Similarly, projector-based tracing offers a practical alternative by enabling direct image transfer onto surfaces. This method is generally faster and requires minimal artistic skill, as users can trace projected outlines with relative ease. However, its effectiveness is highly dependent on environmental conditions. Bright outdoor settings, uneven surfaces, and limitations in projection size significantly constrain its applicability. Furthermore, the method does not actively contribute to spatial learning or skill development, as it relies on passive tracing rather than cognitive engagement.

In contrast, VRGWM introduces a hybrid approach that integrates immersive visualisation with physical execution, effectively bridging the gap between digital perception and manual drawing. As established in earlier studies (Saaid et al., 2026A; Saaid et al., 2026B), VRGWM operates through a VR–Wall iterative loop, where users alternate between virtual observation and physical sketching. This process enables participants to internalise spatial relationships, proportions, and composition before translating them into real-world execution.

One of the most significant advantages of VRGWM lies in its ability to enhance spatial cognition. Unlike grid-based drawing, which requires users to interpret abstract divisions, VRGWM allows participants to perceive the mural composition holistically at full scale. Consistent with Wilson's (2002) account of embodied cognition, this immersive experience supports learning constructed through direct interaction between perception and action, rather than through abstract symbolic interpretation. Consequently, users are able to develop a more intuitive understanding of spatial relationships, reducing reliance on technical drawing skills. Another key advantage is the inclusivity of the VRGWM approach. While both grid and projector methods offer varying degrees of accessibility, VRGWM uniquely enables non-professional users to engage confidently in mural production. The guided nature of VR visualisation reduces cognitive load, allowing participants to focus on execution rather than interpretation. This aligns strongly with Kolb's (1984) experiential learning cycle and with TVET principles more broadly, where learning is centred on hands-on experience and progressive skill acquisition. In this sense, VRGWM transforms mural production from an artist-dependent activity into a transferable skill that can be learned and scaled.

From an efficiency perspective, VRGWM demonstrates clear benefits, particularly during the base-sketching phase. Conventional methods often require extensive preparation, such as grid construction or projector setup, which can be time-consuming and context-dependent. In contrast, VRGWM enables rapid visualisation and direct translation into wall sketches, significantly reducing the time required for initial layout development. This efficiency is further enhanced through the iterative VR–Wall loop, which allows continuous refinement without restarting the process.

Despite these advantages, VRGWM is not without limitations. The reliance on VR hardware introduces constraints related to cost, accessibility, and operational readiness. Unlike grid methods, which require minimal tools, VRGWM depends on specialised equipment such as headsets and applications. Additionally, the current implementation is typically limited to a single user per device, reducing its effectiveness in large collaborative settings. These

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limitations highlight the need for further development, particularly in multi-user VR environments and cost optimisation.

To provide a clearer comparison, Table 3 summarises the key differences between VRGWM and conventional mural techniques.

Table 3: Comparative Analysis of Mural Drawing Methods

Criteria	VRGWM	Grid Method	Projector Tracing
Sketching Speed	Fast	Moderate	Fast
Skill Requirement	Low–Moderate	High	Low
Accuracy	High	Moderate	High
Scalability	Flexible	Large-scale	Limited
Accessibility	High	Moderate	High
Collaboration	Limited	High	Moderate
Cost	High	Low	Low–Moderate
Environmental Dependency	Low	Low	High
Pedagogical Value	High	Moderate	Low

The comparison illustrates that VRGWM excels in areas related to spatial understanding, inclusivity, and pedagogical value. While projector tracing offers comparable accuracy, it lacks the cognitive and educational benefits associated with VRGWM. Similarly, although the grid method remains advantageous for collaborative large-scale work, it does not provide the same level of intuitive spatial guidance.

Importantly, VRGWM represents more than a technical improvement; it signifies a shift in how mural skills are conceptualised and taught. By integrating immersive technology with manual execution, VRGWM aligns with contemporary educational paradigms that emphasise experiential learning, digital literacy, and adaptive skill development. This positions VRGWM as a forward-looking approach that responds to the demands of digital transformation and the evolving landscape of creative industries.

Furthermore, the introduction of VRGWM contributes to the emergence of new forms of creative labour. As digital tools become increasingly integrated into artistic practice, the role of the mural artist is evolving from a purely manual craftsperson to a technologically enabled practitioner. This shift opens new opportunities within the TVET ecosystem, where learners can acquire hybrid skills that combine artistic expression with digital competency.

Practical and Pedagogical Implications

These findings carry practical implications for TVET institutions and community-based art programmes seeking to broaden participation in mural production. Where budgets allow single-device deployment and instructor-guided sessions, VRGWM is particularly well suited to introductory and skill-building contexts, in line with the accessibility and pedagogical-value ratings in Table 3. Conversely, in large-scale, multi-participant public art projects where budget constraints are significant, the grid method remains the more practical choice despite its steeper skill requirement, while projector-based tracing may serve well-lit indoor settings requiring rapid turnaround. Rather than positioning these methods as mutually exclusive, institutions may consider hybrid workflows — for example, using VRGWM for base-sketching and spatial

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planning before transitioning to grid-based or manual finishing techniques for large collaborative murals.

Limitations

Notwithstanding these implications, the findings reported here should be interpreted as propositions to be tested rather than as established outcomes. Because the comparative matrix (Table 3) is derived from qualitative synthesis rather than controlled measurement, the magnitude of the differences between methods — for instance, between "High" and "Moderate" accuracy — cannot yet be quantified with precision. Future empirical work, discussed below, is required to substantiate these propositions.

In summary, while conventional mural techniques remain relevant within specific contexts, VRGWM offers a more comprehensive and future-oriented solution. Its ability to enhance spatial cognition, reduce skill barriers, and support scalable learning makes it a valuable innovation in both educational and community settings. However, its long-term impact will depend on continued refinement, accessibility improvements, and empirical validation in future studies.

Conclusion

This study provides a comparative evaluation of VRGWM against conventional mural techniques, namely the grid method and projector-based tracing, highlighting both their strengths and limitations within contemporary creative practice. The findings suggest that while traditional methods remain effective in specific contexts — particularly in collaborative execution and cost efficiency — they continue to rely heavily on technical skills, environmental conditions, and manual interpretation.

In contrast, VRGWM represents a significant shift in mural production by integrating immersive visualisation with physical execution. This approach enhances spatial understanding, reduces dependency on advanced artistic skills, and expands accessibility for non-professional participants. More importantly, VRGWM introduces a structured and embodied learning process that aligns strongly with experiential learning and TVET pedagogical principles.

Beyond technical advantages, VRGWM contributes to the transformation of mural practice from a skill-exclusive activity into a scalable and inclusive learning framework. It supports the development of hybrid competencies that combine creative expression with digital literacy, reflecting the evolving demands of contemporary education and industry.

While this study is conceptual and demonstration-based, it establishes a critical foundation for future empirical research. To advance from conceptual to empirical validation, future research should adopt a quasi-experimental or mixed-methods design in which novice and semi-skilled participants complete equivalent mural base-sketching tasks using VRGWM, the grid method, and projector-based tracing under counterbalanced conditions. Suggested outcome measures include time-on-task for sketching speed, deviation-based metrics (e.g., percentage dimensional error) for accuracy, validated usability and cognitive-load instruments for accessibility and skill requirement, and pre-post learning-outcome assessments for pedagogical value. Such a design would directly test the propositions generated by the present comparative matrix and provide the statistical evidence needed to substantiate VRGWM's positioning within TVET and digital transformation agendas.

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Overall, VRGWM positions itself not merely as an alternative technique, but as a forward-looking innovation that bridges technology, education, and community-based practice. Its continued development holds strong potential to redefine mural production within the broader context of digital transformation and skills-based education.

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