WACANA SENI
Journal of Arts Discourse

Enhancing Photorealism in Interior Design: Insights and Innovations from PRIDE Framework Analysis

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Published online: 31 December 2025

To cite this article: Mohamad Izani Zainal Abidin, Abdulsamad Alkhalidi, Aishah Abdul Razak, and Fauzan Mustaffa. 2025. "Enhancing Photorealism in Interior Design: Insights and Innovations from PRIDE Framework Analysis." *Wacana Seni Journal of Arts Discourse* 24(Supp. 1): 151–162. https://doi.org/10.21315/ws2025.24.s1.8

To link to this article: https://doi.org/10.21315/ws2025.24.s1.8

ABSTRACT

The evaluation of photorealistic renderings in interior design is often subjective, lacking a standardised methodology to reliably assess the complex interplay between technical proficiency and artistic expression. This paper introduces and empirically validates the Photorealistic Interior Design Evaluation (PRIDE) framework, a comprehensive tool designed to address this gap. The framework's reliability was tested in a rigorous study where a panel of 10 expert assessors, comprising both industry professionals and academics, evaluated a diverse set of 15 interior renderings. The results demonstrate the framework's robustness, showing excellent internal consistency for its technical (Cronbach's α = 0.988) and artistic (α = 0.984) subscales, and strong inter-rater reliability (ICC = 0.782). The primary finding of this study is the data-driven identification of a significant "technique over artistry" gap; renderings consistently achieved higher scores on technical execution than on nuanced artistic elements such as emotional engagement and surface imperfections. The validated PRIDE framework provides a valuable tool for practitioners and educators to benchmark quality and guide development. Furthermore, this work establishes an empirical basis for future hybrid evaluation models, suggesting a path toward semi-automation that combines computational analysis of technical criteria with essential human judgement of artistic merit.

Keywords: *interior design, CGI, photorealistic rendering, framework evaluation*

INTRODUCTION

The emergence of photorealistic rendering has changed the paradigm in the field of interior design (Nikita 2021; Vazquez et al. 2021; Budakov 2024; David et al. 2022). This technology transcends the boundaries of aesthetics and is being employed as a transformational tool to allow designers, clients and stakeholders to plan spaces before they can be physically built. The paper focuses on the issues of high-fidelity visual representation achievement in the interior design context, considering a photorealistic rendering as an example. The success of the photorealistic representation lies in a thin line between technical skills and the perception of art (Dinur 2021; Richter et al. 2023). It calls for ultra-precision in the area of lighting simulation and material definition, as well as camera movement elements, which are firmly rooted in the technical side of computer-generated imagery (CGI). At the same time, however, it requires a deep knowledge of art principles such as harmony of colours, composition, and the ability to fill the spaces with a certain emotional language. This paradox poses a unique challenge: how to integrate in a harmonic relationship the scientific rigour of the CGI and the subtle and subjective strength of the artistic gesture, when even the very concept of photorealism is redefined constantly by changing technology. This paper will respond to this challenge by putting forward a detailed framework called PRIDE (Photorealistic Rendering Interior Design Evaluation) that can provide a benchmarking tool. The scope of criteria included, both technical and artistic in its definition, allows practitioners to have a systematic approach of assessing and enhancing the photorealism of their renderings. However, the proposition of such a framework should be empirically tested since it has to be not only descriptive but also a reliable and consistent test instrument. To counter the above, the current paper justifies the PRIDE framework by means of systematised evaluation on a collection of 15 pictures and a panel of 10 professional and academic expert raters. This experiment aimed at strictly testing the inter-rater reliability of the framework and its internal consistency, which would determine its usefulness in standardised quality assessment when it comes to the discipline of photorealistic interior design.

LITERATURE REVIEW

The development of photorealistic rendering has significantly changed the sphere of interior design so that designers are allowed to imagine spaces with more precision and artistic representation. In this section, some of the influential theories and past literature that have developed the present knowledge of photorealistic rendering are reviewed, and the major contradiction of technical implementation and artistic interpretation is still evident. One of the major themes in the literature is the balance between technical skills and creative input. According to Schmidt et al. (2016), the technical work is not the only focus in order to develop photorealism, but major artistic editing is necessary (Zsolnai-Fehér et al. 2020; Zhu et al. 2024). This brings to light the importance of scientific accuracy to be combined with the sense of art detail in order to create powerful visual effects. This view is supported by the recent research on generative AI in design, which suggests that, although technology may be able to automate the technical design process, it requires human artistic supervision in order to produce quality results (Zhang et al. 2023; Iranmanesh and Lotfabadi 2024; Chen et al. 2025). The dilemma is thus to find methodologies that respect both domains equally.

Literature, in/technical front, is dedicated to the pillars of rendering. It is indicated that the realism of lighting and textures can have a strong effect on the sensual experience of the space by the viewer (Stojanov et al. 2016). Specific aspects of the technical side have been explored, and Cardoso (2017) mentions that proper distribution of light is needed to create depth and mood. Lanier (2018) mentions that the level of development of technologies in 3D lighting has allowed for the creation of more advanced depictions. Stojanov et al. (2016) and Skala, Muža, and Mrvac (2010) went further, investigating the significance of texture mapping, the development of a shader and clear render settings to make any material appear more realistic and generate an image without noise. Artistically and perceptually, the literature explores the relationship between the renderings and the viewer. Chandramouli (2021) pays attention to the harmony of colours and space. This is consistent with Nogueira et al. (2014) and Li et al. (2022), who address the psychological and emotional aspects of visual storytelling. Their results show that the correct use of colour, light, composition and appropriately depicted reflections can be used to elicit specific emotional responses. This is enhanced by Fleming (1998), who coined the term imperfect perfection, where he proposed that the authenticity of perfection was promoted by the slightly realistic failures. Dominici et al. (2023) build on it by examining how depth of field is used strategically not only as a part of technical means, but also as an artistic tool to direct the focus of the viewer.

Overall, the photorealistic rendering is represented as a complex idea in the literature. Individual research has produced an in-depth analysis of specific elements of lighting physics to emotional composition, but there still remains a large gap between a comprehensive and holistic approach to analysis. Most of the evaluations are either subjective or favour either the technical or the artistic qualities. The PRIDE system was designed to fill this gap by providing specific and distinct expectations for both the technical and the artistic aspects of a rendering. The next verification of this framework, the topic of this paper, is to provide the field with a reliable tool that would help to fill the gap between technical performance and artistic presence, avoiding the typical problem of rendering failures and defining explicit standards of quality.

METHODOLOGY

This research will be in two main stages. The initial step proposes the creation of the PRIDE model. The second, larger stage explains the approach to the empirical validation of the framework, which in turn directly responds to the requirement to achieve reliability and systematic evaluation.

Phase 1: PRIDE Framework Development

The PRIDE framework is a methodical model to examine photorealistic depictions within interior design, which consists of parameters of technical skills and artistic manifestation. The selection of the criteria was based on a comprehensive literature review to ensure that there was an evidence basis. The results of Cardoso (2017) and Stojanov et al. (2016) on the basic components of photorealism were used to inform the technical requirements in terms of lighting, materials, and camera settings. Such artistic features as the involvement of emotions and visual narration were included according to the works of Nogueira et al. (2014) on the perception of viewers. Furthermore, the professional standards, especially in terms of surface defects, as well as reflection precision, were incorporated depending on the industry standards that distinguish the quality renderings (Fleming 1998). This scientific method of choice guarantees a thorough analysis of technical and artistic expression. The criteria have been put into two main dimensions: Technological and Artistic, in the hierarchy to highlight the interdependence of the criteria in the production of the more appealing renders, as explained in Table 1.

Phase 2: Framework Gating of Methodology

In order to evaluate the reliability and validity of the PRIDE framework, a formal validation study was carried out. The stage was aimed at giving empirical information that shows the consistency and objectivity of the framework to various evaluators.

Participants (Assessors)

Ten professional evaluators (N = 10) were selected to take part in the study. A balanced mix of five professional CGI artists with many years of experience in the industry and five academics in the creative media and digital design was selected to serve on the panel. This two-way perspective served to make the framework criteria sound and strong, both from a practical, industry-related perspective and from the theoretical, academic view. Each of the participants had significant experience in the assessment of digital imagery.

Materials (Image Selection)

The assessment was based on 15 curated interior design renderings (Figure 1). In order to have a sound and thorough analysis, image selection was done through a stratified sampling method. The selection of the images was deliberate to showcase the high range of quality, including bad or mediocre work, as well as the top quality of the work, which is professional. This was to demonstrate the PRIDE framework's capability of differentiating among the varying degrees of quality, and not just establish the quality of great pictures. In order to make the framework flexible and universal, diversification of the interior design styles (e.g., modern, traditional, eclectic) was made. Nonetheless, to normalise the assessment and reduce the amount of confounding variables, all the chosen pictures showed residential interior spaces.

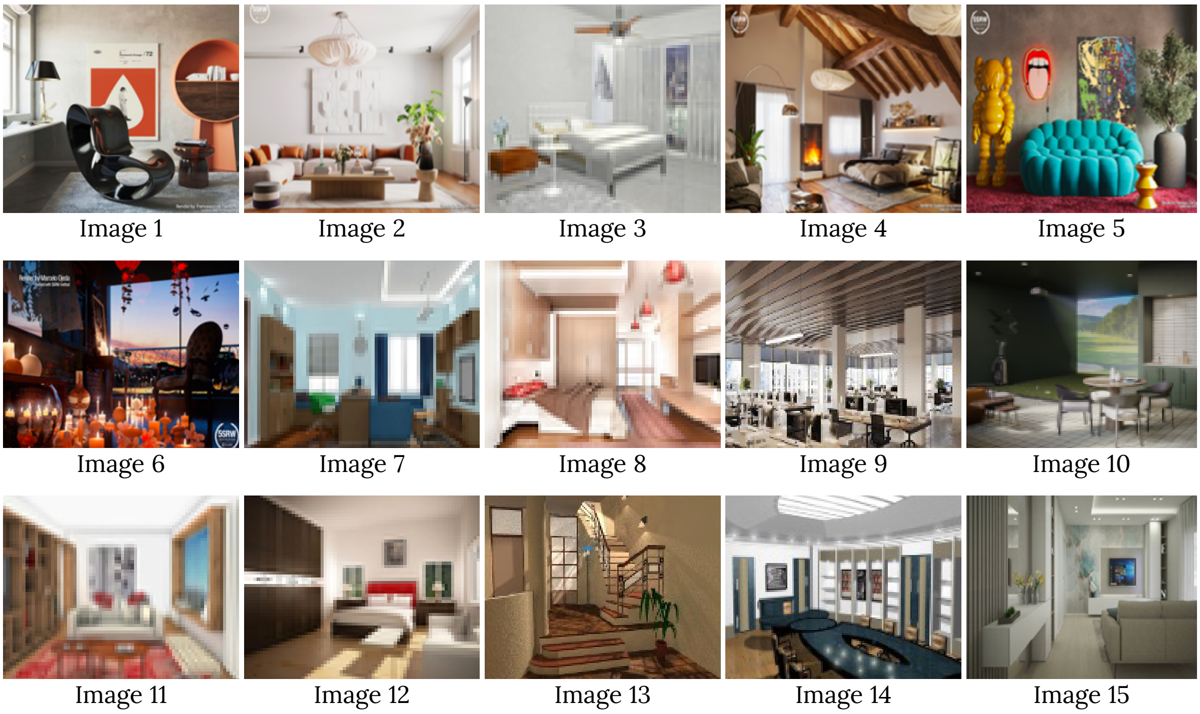

Figure 1 Images used for PRIDE analysis

Procedure and Instrument

An evaluation instrument was created using the 5-point Likert scale, where assessors rated each of the 15 images against the 10 criteria of the PRIDE framework (1 = Poor, 5 = Excellent). Prior to the assessment, all participants attended a 30-minute training session to ensure a standardised understanding of each criterion and the scoring protocol. Following the training, assessors independently rated the 15 images, which were presented in a randomised order to prevent bias and order effects (Figure 2).

Data Analysis

Analysis of the quantitative data will be done on the 10 assessors to establish the reliability of the framework. In particular, the Intraclass Correlation Coefficient (ICC) will be used to determine

Inter-Rater Reliability since it will be used to evaluate the extent to which assessors agree with each other. The Cronbach's alpha will be used to assess the internal consistency of the Technical and Artistic subscales. Such statistical measurements will give the factual data that will prove the PRIDE model to be a constructive instrument to assess the photorealistic images.

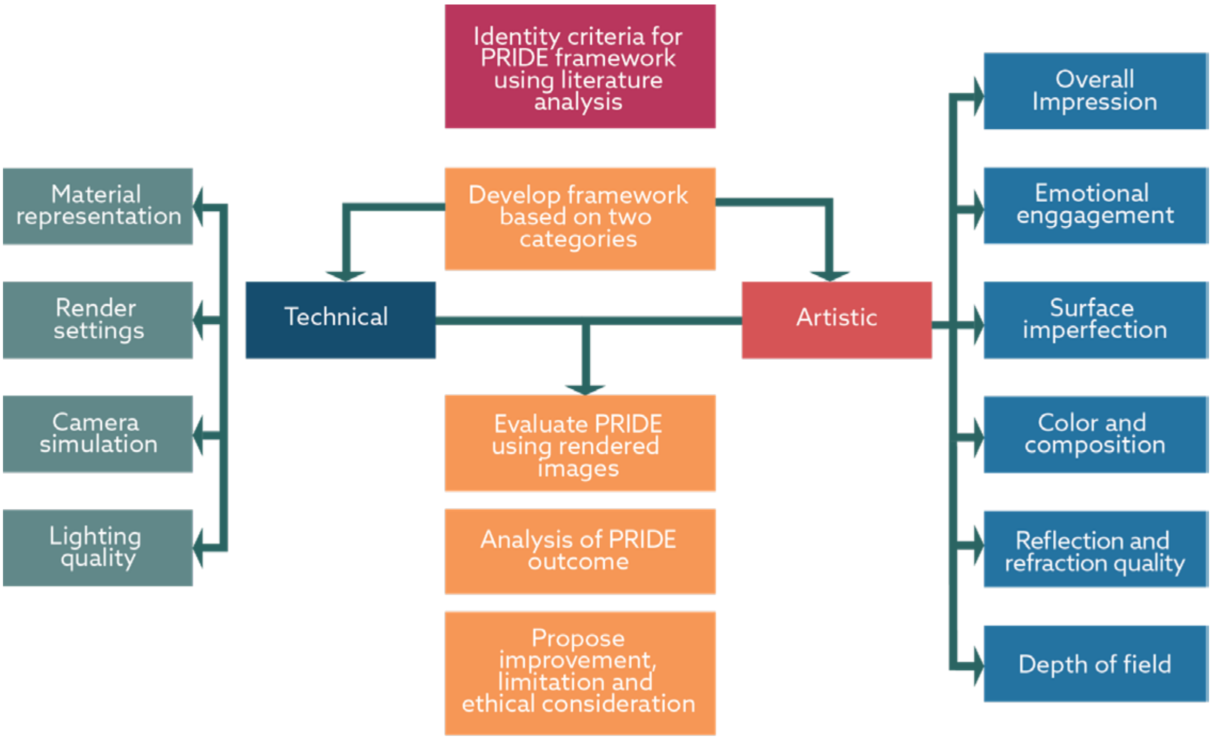

Figure 2 Systematic process of PRIDE framework development

Table 1 Explanation of the criteria

Category	Criteria	Explanation
Technical proficiency	Lighting quality	Check for accurate light distribution and fall-off. Assess whether the lighting adheres to the inverse square law.
	Material representation	Evaluate texture fidelity and ensure materials reflect realistic properties like reflectivity and roughness.
	Render settings	Verify the application of HDR environment lighting and appropriate render settings, including depth of field and noise reduction.
	Camera simulation	Confirm that camera settings (aperture, scale, motion blur, ISO) are true to real-world photography.
Artistic expression	Colour and composition	Ensure the colour scheme is harmonious and the composition effectively utilises the space.
	Emotional engagement	Determine if the rendering successfully elicits the desired emotional response.
	Surface imperfections	Look for the inclusion of realistic imperfections on surfaces and materials.
	Reflection and refraction quality	Evaluate the precision of reflections and refractions within the rendering.
	Depth of field	Confirm the appropriate use of depth of field for enhancing the rendering's realism.

The lessons learned in this overall analysis will be used to set the standards of a successful photorealistic image, including realism, artistic consistency, emotional appeal and aesthetic effectiveness. The framework will harmonise the artistic concepts and the technical rendering processes to give the artists a blueprint to achieve a harmonious balance between technical accuracy and expressing their artistic concepts in their work. The end result of this holistic approach is to make the rendering process more effective, and the achievements are both technically proficient and aesthetically interesting.

RESULTS

This section gives the results of the validation research of the PRIDE framework. It starts with a quantitative assessment of the reliability of the framework, which was a major requirement of the review process. After the statistical confirmation, a qualitative overview of the features that made the high- and low-scoring renderings, according to the overall evaluation of the expert panel, is given.

PRIDE Framework: Statistical Support

To ensure the PRIDE framework's usefulness is empirically supported, two important statistical tests were conducted on the data that was gathered with the help of the 10 professional judges on the 15 pictures. The next sections describe the findings of the internal consistency and inter-rater reliability.

Internal Consistency and Overall Criteria Performance

Internal consistency was measured to determine whether the criteria within the two primary dimensions of the PRIDE framework (Technical Proficiency and Artistic Expression) were genuinely related and reliably measuring the same underlying construct. Cronbach's alpha (α) was calculated for each subscale.

The results, summarised in Table 2, indicate excellent internal consistency for both subscales. The Technical Proficiency subscale, comprising four criteria, yielded a Cronbach's alpha of $\alpha = 0.988$. The Artistic Expression subscale, comprising five criteria, also yielded a Cronbach's alpha of $\alpha = 0.984$. These high values strongly suggest that the items within each subscale are cohesive and effectively measure their respective dimensions of technical skill and artistic expression.

Table 2 Internal consistency of PRIDE framework subscales

Subscale	Number of criteria	Cronbach's alpha (α)
Technical proficiency	4	0.988
Artistic expression	5	0.984

To further understand the overall performance across the evaluated images, the average scores for each of the 10 PRIDE criteria were calculated across all 150 assessments (10 raters × 15 images). The results are visualised in Figure 3.

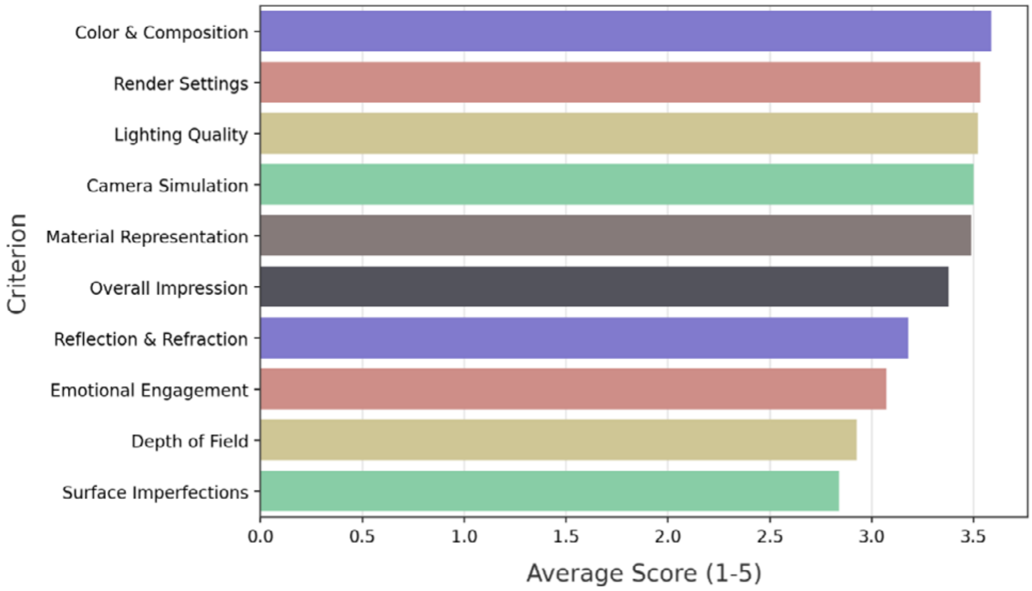

Figure 3 Average score for each PRIDE criterion across all images and raters, sorted in descending order

The analysis of the average scores reveals a clear pattern. The four highest-scoring criteria—Material Representation, Render Settings, Lighting Quality, and Camera Simulation—all belong to the Technical Proficiency subscale. Conversely, the criteria receiving the lowest average scores were predominantly from the Artistic Expression subscale, specifically Surface Imperfections, Emotional Engagement, and Depth of Field. This finding suggests that while the evaluated renderings demonstrate a high degree of technical skill, they are weaker in the application of subtle artistic nuances that contribute to deeper realism and emotional impact. This pattern will be explored further in the qualitative analysis.

Inter-Rater Reliability

Inter-rater reliability was assessed to determine the level of agreement among the 10 expert assessors when using the PRIDE framework. The ICC was calculated based on a two-way random-effects model for absolute agreement.

The analysis revealed a high degree of reliability. The overall ICC for average measures was ICC = 0.78, with a 95% confidence interval ranging from 0.64 to 0.90. This result is statistically significant [F (14, 126) = 45.75, $P < 0.001$] and indicates a strong level of consistency among the raters. The findings, detailed in Table 3, confirm that the PRIDE framework can be used by different experts to produce highly similar and consistent evaluations.

Table 3 Inter-rater reliability of the PRIDE framework (ICC2)

Model	Type	ICC	95% confidence interval	F-statistic	*df*1	*df*2	P-value
Two-way random	Agreement	0.782	0.64, 0.90	45.75	14	126	< 0.001

Qualitative Analysis Based on PRIDE Framework Assessment

Following the successful statistical validation of the PRIDE framework, a qualitative analysis was conducted to interpret the patterns observed in the assessors' scores. To visualise the key differentiators, the assessed renderings were grouped into high-scoring (top 5) and low-scoring (bottom 5) cohorts. The performance of these two groups across the PRIDE criteria is compared in Figure 4. This comparison provides a clear data-driven foundation for the qualitative findings, illustrating the specific areas where high-performing images excelled and lower-performing images faltered.

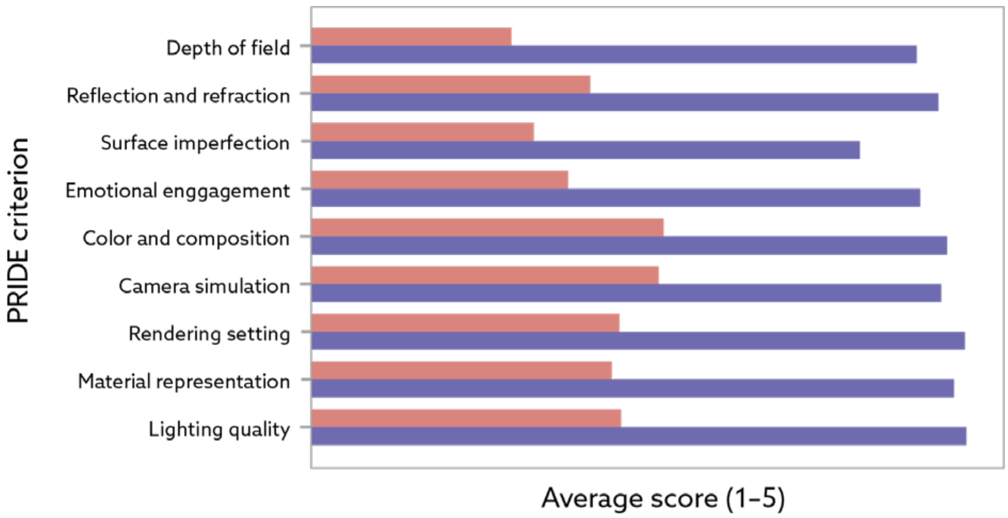

Figure 4 Comparison of average PRIDE criteria scores for the top five high-scoring and bottom five low-scoring renderings

Defining Traits of High-Scoring Renderings

As visualised in Figure 4, renderings that consistently received high average scores from the expert panel excelled across nearly all criteria, but particularly in the domain of Technical Proficiency. Assessors rewarded images that demonstrated a mastery of the foundational elements of CGI. Key strengths included:

Material Representation

High-scoring images displayed materials with convincing micro-surface details, such as accurate roughness and specular responses, avoiding a generic or "plastic" appearance.

Lighting and Shadow

The most successful renderings featured nuanced and physically plausible lighting. This was characterised by soft, accurate shadows, well-controlled dynamic range without blown-out highlights or crushed blacks, and realistic light bounce.

Technical Cleanliness

Images were rewarded for being free of technical artefacts. This included a lack of distracting noise, fireflies, or aliasing, indicating proficient management of render settings.

Common Weaknesses in Low-Scoring Renderings

Conversely, the performance gap for renderings that received lower average scores was most pronounced in the more subtle, artistic aspects of photorealism. Echoing the trend observed in Figure 2 and sharply highlighted in Figure 3, the most common weaknesses identified by the assessors fell under the Artistic Expression subscale include:

Lack of Surface Imperfections

Many images were penalised for appearing too perfect or sterile. The absence of subtle, context-appropriate wear, dust, or minor blemishes made scenes feel less authentic and lived-in.

Weak Emotional Engagement

A frequent critique was that scenes lacked a clear mood or narrative. Lower-scoring images were often described as emotionally flat, failing to use colour, light, and composition to evoke a specific feeling or tell a story.

Gimmicky Depth of Field

In several cases, a shallow depth of field was applied in a way that assessors found distracting or optically implausible, rather than using it to purposefully guide the viewer's eye, detracting from the overall realism.

DISCUSSION

This study sets out to develop and empirically validate the PRIDE framework as a reliable tool for assessing the quality of interior design renderings. The results of the validation study provide strong support for the framework's utility. The high internal consistency (Cronbach's $\alpha > 0.98$) and strong inter-rater reliability (ICC = 0.782) confirm that PRIDE is not merely a descriptive checklist but a robust and consistent instrument for evaluation. This section interprets these findings, discusses their implications for professional practice and education, and addresses the framework's current limitations and potential for future automation.

Interpretation of Key Findings: The "Technique over Artistry" Gap

The most significant finding from the analysis is the clear and consistent performance gap between the Technical Proficiency and Artistic Expression subscales. As evidenced by the overall criteria scores (Figure 3) and the comparison between high- and low-scoring renderings (Figure 4), the expert assessors consistently identified technical execution as a relative strength across the image set. This suggests that current rendering tools and educational pipelines are highly effective at teaching the foundational skills of CGI, such as creating clean renders and plausible materials. However, the data also reveals that the criteria differentiating a competent rendering from a truly exceptional one lie within the artistic domain. The lowest-scoring criteria—Surface Imperfections, Emotional Engagement, and Depth of Field—are those that move beyond technical simulation into the realm of visual storytelling and authenticity. This "technique over artistry" gap indicates that while many practitioners have mastered the software, the next frontier for achieving photorealism is the deliberate and subtle application of artistic principles that makes a space feel not just realistic, but real. This core finding is summarised in the conceptual model (Figure 5). This model, derived from the study's findings, illustrates that while both dimensions are essential for achieving true photorealism, the "Artistry Gap" is often the primary factor limiting the quality of renderings.

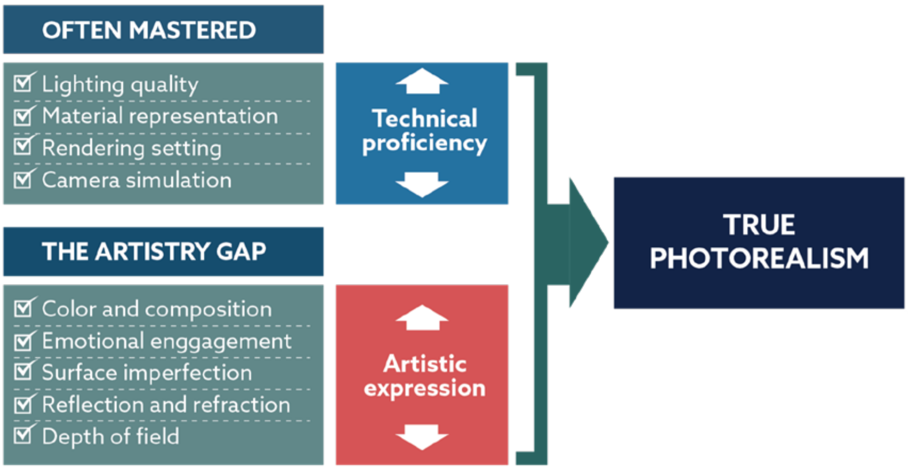

Figure 5 The Technique-Artistry Imbalance Model

Implications for Practice and Education

The validated PRIDE framework and the identification of the artistry gap have significant implications. For professional practitioners, the framework offers a standardised tool for self-critique and quality assurance, enabling them to pinpoint specific weaknesses beyond technical errors. For educators, PRIDE provides a structured rubric that can be used to deliver more objective and comprehensive feedback to students, ensuring that curricula emphasise not only software proficiency, but also the artistic nuances of composition, mood, and imperfection that are critical for professional-level work.

Generalisability and the Path to Automation

It is important to note that the PRIDE framework, in its current form, operates as a manual evaluation tool. While this human-centric approach is currently essential for capturing the nuance of artistic expression, we acknowledge the need for scalable solutions. The structure of PRIDE lends itself to a future semi-automated or hybrid evaluation model. The criteria within the Technical Proficiency subscale are strong candidates for future automation. For instance, Render Settings could be partially assessed by algorithms designed to detect noise or fireflies, while Lighting Quality could be analysed through histogram luminance and shadow contact analysis. In contrast, the criteria within the Artistic Expression subscale, such as Emotional Engagement, are inherently subjective and would likely always require expert human judgement. Therefore, we propose that the future of rendering evaluation lies not in full automation, but in a hybrid system where computational analysis provides a baseline technical score, freeing up human experts to focus their efforts on the more nuanced artistic assessment. This approach would combine the efficiency of machines with the indispensable insight of the human eye.

Limitations and Future Research

This study successfully validated the PRIDE framework, but it is not without its limitations. The validation was conducted using a sample of renderings exclusively from residential interior spaces. Future research should test the framework's applicability and reliability on a broader range of contexts, such as commercial interiors, architectural exteriors, and product visualisation. Furthermore, the assessor panel consisted solely of experts. An interesting avenue for future study would be to compare the results of expert raters with those of novice users or clients to understand how perceptions of photorealism may differ across audiences.

CONCLUSION

This research successfully addressed a critical need for a standardised evaluation method in photorealistic interior design by empirically validating the PRIDE framework. Through a rigorous study involving a panel of 10 expert assessors and a diverse set of 15 renderings, this paper has provided the statistical evidence required to establish PRIDE as a reliable and consistent tool for evaluating both the Technical Proficiency and Artistic Expression inherent in high-quality CGI. The primary contribution of this work is the data-driven identification of the "technique over artistry" gap. Our findings clearly indicate that while technical skill is a common and well-mastered competency, the mastery of nuanced artistic elements, such as emotional engagement, visual storytelling, and the deliberate application of imperfections, is the ultimate differentiator that elevates a rendering from being merely realistic to truly believable. The implications of these findings are significant for both professional and educational contexts. The PRIDE framework offers practitioners a robust tool for self-critique and quality control, while providing educators with a structured rubric to cultivate a more holistic skill set in the next generation of digital artists. Looking ahead, as the field evolves with the rise of generative AI and increasingly sophisticated tools (Bhaskarla et al. 2025), the ability to critically assess and purposefully direct the artistic dimension of digital creations will become increasingly paramount. This study not only provides a validated tool for today's needs but also champions a future where a hybrid of efficient computational analysis and indispensable human artistic judgement defines the pinnacle of photorealism.

ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to all experts involved for their valuable reviews and insightful contributions. The authors also extend their appreciation to all individuals who contributed, directly or indirectly, to the data collection process.

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